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New England Association of Chemistry Teachers.

Report of Eighth Meeting.

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Report of Eighth Meeting.

The eighth regular meeting of the Association was held on Saturday, April 14, 1900, at 2 P. M., Room 35, Walker Building, Massachusetts Institute of Technology, Boston, President Rufus P. Williams in the chair. Fifty-six members and visitors were present.

The minutes of the seventh regular meeting were corrected by the addition of: "Mr. Oliver P. Watts, of Waltham, and Mr. A. P. Campbell, of Quincy, were elected to active membership."

The executive committee recommended Miss Nettie M. Willey, of Peabody, Mass., and Mr. Guy M. Winslow, of Lasell Seminary, Auburndale, Mass., for active membership, and Mr. W. G. Whitman, Gloucester, Mass., Mr. James W. Burke, Westerly, R. I., Mr. Dudley L. Whitmarsh, Whitman, Mass., Mr. Charles T. Guildford, Tilton, N. H., Mr. Charles H. Noyes, Nashua, N. H., Mr. Charles W. Marston, Skowhegan, Me., Mr. Herbert E. Sargent, Wolfboro, N. H., and Mr. Wallace E. Richmond, No. Adams, Mass., for associate membership; and upon the ballot all were elected.

The following addition to Article 5, Section 1, of the Constitution had been proposed at the previous meeting by Mr. Williams: "The same president shall not be eligible for election two consecutive years." After discussion, the motion of Mr. Sheldon, to refer the matter to the executive committee to recommend such action as they saw fit, was lost by a tie vote. On motion of Mr. Holden, it was voted to indefinitely postpone action.

The president announced the first death among the members of the Association, and Miss Laura B. White read a tribute in memory of Miss Grace H. Perkins, who died March 31, 1900. It was voted, upon motion of Miss White, that the following resolution be adopted: "As teachers of chemistry with Miss Perkins, we desire to express to her relatives and friends, first of all, our heartfelt sympathy for them in their sorrow; and after that, our deep sense of personal loss, loss to the subject of chemistry and loss to the teaching profession. At the same time we do not forget to be grateful for her strong, quiet presence among us, and for the inspiration of her conscientious, thorough service."

Dr. Newell, chairman of the committee on circulars, reported that the first of these — Circular of Information 1 — had been printed, and that copies were ready for distribution.

Dr. Newell, chairman of the committee to prepare a list of books on chemistry, reported that the work was nearly finished, and that the list would probably be ready in June.

The following report of the committee on Physical Chemistry was read by Dr. Hubert G. Shaw:—

Certain Anomalies in Mendeléeff's System. (Behrens.) Isomorphism between tellurates and sulphates is denied by Retgers, who, in consequence, assigns tellurium to group eight between ruthenium and osmium, disregarding the similarity between hydrogen telluride and hydrogen sulphide, and recognizing the isomorphism of compounds having the formulas K_2TeCl_6, K_2OsCl_6 and K_2IrCl_6. But tellurium is isomorphous with tin (in the compounds Cs_2TeCl_6 and Cs_2SnCl_6), and tellurium dioxide dissolves in acid potassium oxalate forming crystals like those of potassium zirconium oxalate. This might serve as an argument for placing tellurium in the fourth group with tin and zirconium. Again, if tellurium be placed between ruthenium and osmium seventeen new elements must be looked for in that group. With manganese similar questions might be raised, as potassium permanganate is isomorphous with potassium perchlorate, and potassium manganate with potassium sulphate. Behrens' conclusion is that, "Isomorphism is not to be rashly used as a guide to positions in the table."

Molecular Weight of Iodine. (Oddo and Serra.) By the boiling point method, using benzol as a solvent, the molecular weight of iodine was found to be 273–279 (about two atoms in the molecule) using ethyl alcohol 265–327. When carbon tetrachloride was used as a solvent the result led to the conclusion that the molecule contained eight atoms.

Atomic Weight of Boron. (Gautier.) Boron tribromide was obtained by passing pure bromine over red hot boron. This was fractionally distilled alone, then over reduced silver. (B. Pt. 90.5). Boron trichloride was made in a similar way. Weighed quantities were decomposed by water and the halogen determined by silver.

Results:	(Bromide)	B= 11.021	+ .006
	(Chloride)	B= 11.011	+ .008

Average 11.016.

Solidification of Hydrogen. (Dewar.) Liquid hydrogen allowed to evaporate at a pressure of .3– .4 cm. solidified at a temperature of about 16° absolute. The specific gravity of the liquid was about .086, its boiling point under 76 cm. pressure about 21° absolute. Computation shows that the critical temperature of hydrogen must be 30°–32° absolute. The lowest temperature thus obtained is 14°–15° absolute.

Preparation and Properties of Argon. (Ramsay and Travers.) Atmospheric nitrogen was passed over heated magnesium and copper, next over a red hot mixture of lime and magnesium, then over red hot cupric oxide. The residual gas was liquefied in a bath cooled by liquid air. On distillation the first portion is rich in neon and contains helium. The least volatile portion is metargon. The middle portion is argon. This was purified by redistillation. The density was found to be 19.957 (former experiments showing 19.94). The refractivity was .9665. No tendency to polymerize was observed.

The report of the committee on current events was read by Miss Eliza E. Andrews. References to the material contained in these reports will appear in a subsequent circular of information.

Dr. A. C. Hale remarked upon the experiments of Pictet now going on in New York, whereby oxygen considerably over 90% pure is obtained from liquid air by boiling out the nitrogen and other gases at a regulated temperature.

The president announced that the Perry Pictures Co. would undertake to reproduce portraits of eminent chemists and alchemists, available for teachers and pupils of the science.

Mr. John W. Dow, of the Roxbury High School, exhibited samples of about seven hundred chemical substances, and gave the following account of their collection and preservation :

The need of a set of samples of common chemical substances was brought to my attention very forcibly by the lack of knowledge on the part of a large number of pupils about the common reagent substances. That barium chloride, silver nitrate, sodium hydrate and hydrochloric acid were liquids was the prevalent answer, proves that further attention should be paid to the properties of every day chemicals. The reason for this error is simple: the pupil sees the substance in solution every time he comes to the laboratory, rarely, if ever, in the solid form, My effort has been to produce a cheap, practical set of chemicals, easily examined. and handleable with a minimum of breakage, and above all, to keep this set before the eyes of the pupil. Thus only can the pupil become familiar enough with the chemicals he uses,— that, instead of being imaginary, visionary things with a given formula, they are actual realities.

I have had made specimen tubes of thick soft glass, three inches long and about half an inch in diameter. In these I have put samples as characteristic as possible of all the various chemicals which I ever mention to a pupil. The tubes were sealed by driving a well-rolled cork as far as possible, cutting off the protruding part and driving it in that a depth of about a quarter of an inch was left above the cork. This space I filled with very hot sealing wax. This makes, I think, an air tight seal, as I have had no trouble with deliquescent salts. Liquids I have sealed in the tubes by the blast lamp, using this method only with liquids and very corrosive substances, to obtain greater uniformity of appearance. In labeling I have used Dennison's No. 3219, pasting them on lengthways the tube. In addition to the formula I have stated when practicable the method of preparation. The samples are kept in a bookcase, the shelves being tipped enough to insure easy view. The pupil is encouraged to handle and examine.

The tubes cost $1.70 a gross. This, with the expense of the label and stopper, would make the cost about two cents apiece exclusive of the chemicals.

A sample of crystallized silicon was shown by the president.

Dr. F. G. Benedict, of Wesleyan University, was then presented. He spoke on the "Respiration Calorimeter and Experiments on the Metabolism of Matter and Energy in the Human Body":—

The object of the experiments from the standpoint of the chemist is to measure both the matter and the energy of the food given to the subject, and also those that come from him. For this purpose a human being is confined for

several days in a large calorimeter. This is a room about 2.15M.x1.22M.x1.92M. The corners are somewhat rounded, giving a capacity of about five cubic meters. It consists of five concentric boxes. The inner box is of copper, the next of zinc, which is placed at a distance of 7.6 cm. These two boxes are fastened together by a wooden framework, and are covered by three more boxes of wood, enclosing two air spaces. An opening at the front end 70 cm. high and 49 wide serves both as a window to admit light and as an entrance. During each experiment, after the subject has entered the box, the glass is fastened in with putty. Food or other material is handed in or taken out through a tube, screw-capped on both ends. If the outer cap be removed, the substance placed in the tube, and then the cap replaced, little if any unmeasured air would enter or escape when the inmate removed the inner cap to take out the articles. A folding cot, a chair, and a folding table compose the furnishings of the room. A telephone and an electric bell are furnished so that the subject may at any time summon an attendant or communicate with the outside world.

By a system of cold water pipes around the top of the calorimeter the temperature can be kept constant and the heat reduced as fast as generated. Hygrometer readings are made at frequent intervals by the occupant and reported by telephone.

Air is taken from out doors and cooled by passing through tubes surrounded by brine artificially cooled by means of an ammonia refrigerating machine to —20° C. to remove the moisture, and, before entering the chamber warmed to a suitable (observed) temperature by a sixteen candle power incandescent lamp placed in the tube. Some of the moisture coming from the respired air is condensed on the water pipes used for cooling, and is collected in a trough that hangs just beneath them. The air leaving the chamber is passed through cooling tubes to remove the moisture, and measured by a specially devised meter pump. Samples of the incoming and outgoing air are taken continuously.

Proximate and elementary analyses of the various foods and drinks used are made. The meat used is cut into long strips, run several times through a meat chopper, to insure thorough mixing. Bread is cut into slices, alternate slices being taken for eating and analysis. Oatmeal, butter, milk, cheese, sugar, crackers, and ginger snaps also form part of the diet.

The Experiment. For several meals before entering the calorimeter the subject is fed on exactly the same food he would receive while underdoing the experiment. He takes a bath in distilled water and is weighed just before entering the calorimeter, and again at the close of the experiment. The duration of the experiment is from two to twelve days. The weights of the articles of furniture are also taken at the beginning and the close of the experiment, and allowances are made for any difference in the amounts of water they contained. Chemical analyses and determinations of the heat of combustion of solid and liquid excreta as well as the food are made, and careful measurements of the heat given off, as well as the muscular work done by the subject are recorded.

At the close of the experiment the loss or gain of weight of the man is noted. And it has been found that the difference between the food received and the total excrementa equalled the gain or loss in weight. The total energy of the income as measured by the heats of combustion of the food and drink minus that of the

excrementa agrees very closely with the outgo of energy from the subject (both muscular work and heat being taken into consideration), due allowance being made for the storage of fat in the body, or for its consumption. Up to the present time, thirty-four experiments have been made. The results of these experiments and of similar investigations elsewhere bring out clearly the difference in the amounts of nutrients and energy required by the organisms of different persons under different conditions, and confirm the results of previous inquiry in showing that muscular labor is performed at the expense of the fats, sugars, and starches. They also make it clear that the body may draw upon protein for this purpose, although it has not yet been determined just what are the conditions under which this is done.

Upon motion of Hubert G. Shaw, Dr. F. G. Benedict was elected an honorary member.

On motion of Mr. Hutchins, it was voted that the thanks of the Association be tendered for the use of the room and the other courtesies shown by the Massachusetts Institute of Technology.

Adjourned,

HUBERT G. SHAW, *Secretary.*

RUFUS P. WILLIAMS, *President.*

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NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS

Report of the Thirty-fourth Meeting

New England Association Chemistry Teachers

The thirty-fourth regular meeting of the Association was held Saturday, February 13, 1909, in Boston.

PROGRAM

Morning Session at Simmons College

9.45 A. M. Meeting of Executive Committee.

10.00 A. M. Business Meeting.

1. Election of New Members.
2. Report of Committee on Current Events and Publications.
3. Report of Committee on New Apparatus.

10.40 A. M. Review of Wilhelm Segerblom's "Qualitative Analysis" by Owen D. Evans, High School of Commerce, Boston, Mass.

10.55 A. M. Address of Retiring President, Prof. James F. Norris.

11.30 A. M. Address of Prof. Henry P. Talbot, Mass. Institute of Technology.

"Should more credit be allowed by institutions of college grade for work done in chemistry in the secondary schools?"

12.15 P. M. Discussion of Prof. Talbot's Address.

1.00 P. M. Luncheon at Simmons College.

Afternoon Session in Room 6, Lowell Building, Massachusetts Institute of Technology

2.30 P. M. Lecture, "Destructive Distillation" by Prof. F. H. Thorp, Mass. Institute of Technology.

The meeting was called to order by the President, Augustus Klock at 10.20 o'clock.

The first business attended to was the election of new members.

The following candidates, recommended by the Executive Committee, were elected members of the Association.

FOR ASSOCIATE MEMBERSHIP

Angie Gertrude Albee, High School, Ware, Mass.
Fred H. Daye, High School, Bellows Falls, Vermont.
Belle Gleason, High School, Foxboro, Mass.
Caroline H. Mendum, High School, Concord, Mass.
H. Milton Thayer, Oliver Ames High School, North Easton, Mass.
Henry L. Wales, High School, Ludlow, Mass.
Gertrude H. Ware, High School, Webster, Mass.
Howard A. Newton, High School, North Abington, Mass.

REPORT OF COMMITTEE ON CURRENT EVENTS AND NEW PUBLICATIONS

The following report was read by Professor Lyman C. Newell, chairman:

NEW PUBLICATIONS

Government Publications.—The Annual Report of the Smithsonian Institution for 1907 has just been issued and copies may be obtained gratis from the Secretary of the Smithsonian Institution, Washington, D. C. The edition is limited and immediate application is advised. The report for 1907 contains an illustrated article on Progress in Metallurgy and a biographical account of Berthelot, besides

several contributions of interest to teachers of physics and other sciences. A valuable feature of the report is the excellent half tone plates (79 in all), including many portraits.

The United States Geological Survey issues at frequent intervals pamphlets which are advanced chapters of the annual report on mineral resources of the United States. The series for 1907 is about complete and may be obtained gratis from the Director of the U. S. Geological Survey, Washington, D. C. The Survey has issued in connection with these reports a Chart showing the Mineral Products of the United States from 1898 to 1907 (gratis as above.) Those who do not care for the separate pamphlets may cover the ground by the chart just mentioned and one pamphlet entitled Summary of the Mineral Products of the United States for 1907. It must be noted in passing that two of these pamphlets contain maps of permanent educational value, viz., the one on The Production of Coal for 1907 and the one on The Production of Gold, Silver, Copper, Lead and Zinc in the Western States and Territories in 1907. [Professor Newell exhibited these maps to the members of the Association.] Separate edition of these maps is on sale for a nominal sum (25 cents each) by the Survey.

Attention of the members is again called to the fact that U. S. Government publications as a rule are sent only on application. The Geological Survey issues a Press Bulletin frequently which contains announcements of new publications (application as above.) The Department of Agriculture issues gratis a Monthly bulletin from which publications relating to Chemistry may be ordered. The Monthly Bulletin may be obtained on request from the Hon. Secretary of Agriculture, Washington, D. C.

Carnegie Institution. A list of the Publications of the Carnegie Institution of Washington may be obtained by writing to the Carnegie Institution, Washington, D. C. The last list includes titles of many investigations in chemistry.

Reactions. This is the title of a quarterly magazine published by the Goldschmidt Thermit Co., 90 West St., New York, and devoted to the interests of thermit. It will be sent gratis on application.

The international atomic weights for 1909 were spoken of and attention was called to a few corrections.

RECENT ARTICLES

Review of Inorganic Chemistry for 1908. Several items of interest to teachers of chemistry are in this review, which was prepared by Jas. Lewis Hewe and is in the Journal of the American Chemical Society, Feb. 1909, pp. 252-272.

A new radioactive element was announced by Boltwood in 1907. It was named ionium. "It seems well established that ionium is the direct parent of radium. From its properties, ionium seems to resemble thorium and will probably have about the same atomic weight."

For some years the law of the conservation of matter has been studied by Landolt. "The earlier work of Landolt on the possible change of weight in chemical reactions has been gone over again by him. The previous work seemed to show that in certain reactions there is a small but constant loss of weight. Further investigation has shown that the heat of the reaction causes a slight change of volume which affects the weight and does not disappear for some time. After a few days there is apparently a constant weight, but actually the original volume is not reached for several weeks. Subsequent to this time, the weight after the reaction is the same as before within experimental error, so that Landolt's conclusion is that in the fifteen reactions studied there is no change of weight which can be experimentally determined."

The liquefaction of helium has been noted in a previous report. The following is stated solely for reference: "Liquid helium is colorless, has a density of .154 and a boiling point of 4.5° abs. Its critical temperature is about 5° abs. and its

critical pressure is about 2.3 atmospheres. Solid helium was not obtained."

Deflocculated graphite was noted in a previous report. "Two preparations of graphite for lubrication have recently come into the market under the name of oildag and aquadag. They are described by Acheson in the Journal of the Franklin Institute (164,375). Going out from the well known effect of tannic acid on the plasticity of clay, the effect of tannic acid on graphite was investigated by grinding graphite to a very fine condition with three to six per cent of its weight of tannin. The graphite (artificial or natural) was thus obtained in a "deflocculated" or seemingly colloidal state, remaining for months in suspension and passing through the finest filters. On the addition of hydrochloric acid, the graphite is coagulated, and can be settled or filtered, drying to a hard mass which is free from all grit, and the best form of graphite for lubrication."

THE REPORT OF NEW APPARATUS COMMITTEE

Was presented by ALFRED M. BUTLER

A cross section chart with blackboard surface for plotting curves. Chart about 4 feet x 3 feet with squares 1½ inches. Made by Knott.

A mercury storage funnel, for purifying mercury from mechanical impurities. Made by Knott.

A good way to remove the top or bottom from a bottle is to take a round galvanized wire about one-eighth to three-sixteenth inches diameter, square off the end and heat to redness for a distance of 2 to 3 inches from the end. Make a file mark one-eighth inch long on the bottle, where break is desired. Touch the red hot wire to the bottle about one-sixteenth inch from one end of the file mark, hold for 3 seconds, then touch to the bottle 1-16" from other end. If the wire is sufficiently hot, the crack will form where desired and may be continued around the bottle by drawing the hot iron in the right direction. The edge secured by this method is not sharp.

REVIEW OF SEGERBLOM'S QUALITATIVE ANALYSIS

By Owen D. Evans
High School of Commerce, Boston.

Price, introductory, $1.25 Longmans Green & Co., 1908

The author of the book is Mr. Wilhelm Segerblom, Instructor in Chemistry at the Phillips Exeter Academy. The book is a Laboratory Manual, not a text book; it is, in the author's words, "simply a statement of the method that has worked well with the classes at the Phillips Exeter Academy." Being designed primarily for the use of immature pupils, the book is of peculiar interest to teachers of qualitative analysis in secondary school. It contains about 140 pages, all told, and the work outlined may be covered in twenty-seven weeks if the author's suggested schedule is followed.

The point of view from which one regards a text book affects the relative values of what he sees therein. A few comments of a general nature may precede the discussion of the detail of the text. The author evidently knows the limitations of secondary school pupils, and directs himself in an unusually clear and terse style of English to making matters plain to the pupil, rather than to the teacher. He avoids the error of trying to cover too much ground, or of confusing the pupil by multiplying exceptions and special cases. His working rule seems to be one which many of us heartily approve —give the pupil a clean cut, definite problem, and see that he solves it.

Some teachers might prefer a book which has text book features in addition to laboratory work. For instance, the author might have given twenty pages of introductory general principles on the theory underlying the use of group reagents, as is given in Treadwell Hall, in the discussion on oxidizing and reducing reagents.

The author has however, forestalled this criticism by suggesting that many teachers prefer their own demonstrations and lectures, on these points, and that in any case, suitable

reference text books, like Treadwell Hall, should be available for the class.

The next general comment is on the division into Basic Groups. On this point there are many men of many minds. Some elementary text books follow the groups as laid down by Fresenius and develop them in that order; others change the order of the groups in preliminary discussions, and then change them in a different way in the laboratory. This is very confusing to young pupils. Mr. Segerbloom takes the groups as they are given by Professor Noyes, and then unlike Professor Noyes, develops the laboratory work in the same order. This gives a clearness and definiteness to his treatment which ought to be very helpful to secondary school pupils.

And the last general comment concerns this question. If secondary school pupils study qualitative analysis for the sake of training in inductive reasoning, what is to be the subject matter of their inductive reasoning? Will you give the pupil a number of elements of one group, or of several groups, and have him, with the aid of printed directions on procedure, gather a mass of information from which he may infer the differing behaviors of the elements, or groups concerned? Or will the instructor first show the pupil how the elements or groups behave under the action of typical reagents, and then expect the pupil to exercise his powers of inductive reasoning in recognizing or identifying the element under examination? Mr. Segerblom very wisely takes the latter course. To quote from his preface:—

"All the preliminary work given in these pages should be done by the instructor on the lecture desk. The results are printed in full so as to enable the student to devote his whole attention to the phenomena and to the instructor's remarks thereon. A repetition of the experiments by the students individually in the laboratory will clinch this most important foundational work and pave the way for a comprehensive grasp of the methods of separation in the case of unknown substances. Only these reactions that lead to such a grasp

are given ; all others, however interesting, are rigorously excluded. A known solution on each group of bases containing all the members thereof should be analyzed by the instructor in the presence of the class; each student should repeat this work before proceeding with his own unknown solutions."

In detail, some of the distinctive features of the book follow: The work on each group is made clear by a skeleton outline or scheme which shows in graphic form the procedure, and result obtained. The author meets the objection that students may fall into the habit of using such a skeleton outline mechanically by stating that nothing but judicious and frequent questioning by the teacher will keep the pupils from following mechanically any text. A clever device is used in these schemes. A tiny degree mark (°) so small as not to interrupt the student on his first reading, indicates notes giving additional explanation on troublesome points.

All equations which occur in reactions are given in full. This practice makes a tremendous number of equations in the entire book, and might be criticized on the ground that many of the equations might be worked out by the pupil. On the whole, however, this treatment is good. Equations are of great value in making the student understand each step of the work, but young pupils will expend an undue amount of time if they are compelled to work out many of these reactions without assistance. It is another instance wherein the instructor is enabled to give the pupil a definite task, and then to hold him to it.

The typographical work is good. The general text is good clear type, and the use of two different sizes of type distinguishes notes from text. In the outlines two additional forms of type are used, and succeed in giving added clearness.

The list of bases by groups is the same as that of Professor Noyes' text, with the important difference in treatment that Mr. Segerblom develops the groups in the very order in which he first names them. This arrangement is, I believe, peculiar to Mr. Segerblom.

Group I Alkali Group, Na, K, Li, NH_4.
II Alkaline Earth Group, Ba, Sr, Ca, Mg.
III Aluminum Group, Al, Cr.
IV Iron Group, Fe, Co, Ni, Mn, Zn.
V Copper Group, Ag, Pb, Hg, Cu, Cd, Bi.
VI Tin Group, As, Sb, Sn.

This method of treatment has a definiteness, and lack exceptions which makes it very good for secondary school pupils.

In the acid groups are presented only inorganic acids, with the exception of the organic oxalic, tartaric and acetic acids. But three groups are presented, and the procedure after determining the group consists of special tests for each acid. The groups are (p. 71) :

I Acids responding to Ba Cl_2 reaction with subdivision responding to HCl.

II Acids responding to $AgNO_3$ reaction with subdivision responding to NH_4OH.

III Acids not responding to Ca Cl_2 or $AgNO_3$. ,

The analysis of salts proceeds under (a) preliminary dry analysis, (b) basic analysis, (c) acid analysis. Pupils who use this text are supposed to have had a thorough course in elementary chemistry. Teachers who wish to take up the study of qualitative analysis at the end of the first year of elementary chemistry, and to use qualitative laboratory work while carrying on descriptive work on the common metals: iron, nickel, lead, copper, etc., would probably prefer a manual in which the basic group arrangement takes up these metals first. This seems to be the only objection to the author's arrangement of groups.

The appendix of the book contains :

1. A very complete list of books for collateral reading.

2. A suggested schedule for covering the work in twenty-seven weeks.

3. A list of questions, fifteen solid pages, referring to the body of the book, and worked out in such detail as to

compel the pupil to think out an answer at each stage of the work.

4. A complete list and description of reagents and solutions needed, prescribing quality of reagents and strength of solutions.

5. A set of suggestions to the teacher, helpful and suggestive.

6. An index which is accurate and complete.

In conclusion, then, the book is a distinctly valuable addition to the list of texts for secondary schools. It bears on every page the signs of having been tried out in actual use with young students by a teacher who knows their abilities and limitations. Its clear English, accurate directions, sensible suggestions, definite information as to supplies and reagents, and schedule of study, give one a feeling of confidence that it would prove to be a satisfactory book to place in the hands of a class.

AN APPRECIATION

By Sidney Peterson

At our last meeting we were all happy to place among the honorary members the name of Edward F. Holden. We did this not because he is no longer teaching chemistry, and had asked to be relieved of all duties as an officer in our association, but because we wished to honor him. At that meeting nothing was said concerning Mr. Holden, and we should not let this opportunity pass without putting on our records our appreciation of his devotion to our organization.

As one of the charter members, he enthusiastically aided in forming our association. At the second election of officers he was made treasurer, which office he held until he was elected vice-president in 1907. Some men take office because of the honor; some serve because they must; but there are others who are ever ready to serve not for honor but because of the desire to do what they can for the good of all. Mr. Holden is of this last unselfish type. His service was of the fullest possible helpfulness. As a member

of the executive committee, he was of great assistance, not only because of the saneness of his counsel, but because of his knowledge of the history and ideals of the association and his acquaintance with each of the members. As just a plain man, genial, delightfully frank, sincere, and broad-minded, we respect and honor him and are happy to keep him with us.

Mr. Holden thanked the executive committee for the honor conferred upon him and he expressed himself as interested in chemistry although he is not teaching it at the present time.

ADDRESS OF PROF. JAMES F. NORRIS

A brief account of the historical development of the conception of valence was given. This was followed by a brief description of some recent work in inorganic chemistry which has served to enlarge our knowledge of valence. Reference was made to the work of Werner and that on alloys.

Prof. Norris thanked the association for twice electing him to the office of president and said he hoped to be able to take an active part in matters concerning the association.

ADDRESS OF PROF. HENRY P. TALBOT

Should More Credit Be Allowed by Institutions of College Grade for Work in Chemistry in Secondary Schools?

It is easy to believe that many would be willing to add to the query which stands as the subject of this talk the traditional language of the examination paper: "If not, why not? Give reasons for your answer." That which follows represents an effort on my part to bring together some of the reasons, as they appear to me, for the present somewhat unsatisfactory situation with reference to the acceptance of work done in Chemistry in the secondary schools. I have made this attempt at the request of your president, but with considerable reluctance, and not with the hope that I shall be able to say anything which will approximate a final word on the subject, but rather that I might possibly clarify my own ideas

and, by eliciting discussion on your part, ultimately correct them if they are wrong. Let me say at the start that it is perhaps doubtful whether I ought to speak for the colleges, since the data on which my conclusions are to be based are observations made in the laboratory of a technical school in which the instruction in Chemistry becomes a part of a "step up" system of requirements; that is, one in which successful work in subjects of later years is directly dependent upon a thorough grounding in earlier subjects to a degree that does not obtain in the less rigid sequence of studies in the college. It is, however, increasingly true that the attitude of the college and of the technical school should be the same; for not only are the universities offering inducements for their students to enter their own scientific or engineering schools, but the colleges are sending each year more men for postgraduate work in other technical or engineering schools, and it should be as much a matter of concern to them to see that such men have an adequate preparation in science, as to see that they are soundly taught in mathematics, or the humanities. Many of the colleges have much room for improvement in this respect.

Let us first look at the situation as it apparently exists at present in some of our typical institutions as indicated by the following brief summaries. The term "entrance requirement" is assumed to represent the work of a year with the ordinary time allotment for chemistry in the preparatory schools. The data have been obtained through direct correspondence with representatives of the institutions mentioned.

(1) Yale College: Does not require Chemistry for entrance. Students may take an examination for advanced standing, but rarely do so.

(2) Harvard College: Those who have passed the entrance requirement take the same lectures as those who have had no Chemistry, but they also have special laboratory work and more advanced instruction in a special division. They are also allowed to take a first course in Organic Chemistry in the Freshman year. Admission of such students to work in Qualitative Analysis did not prove successful. Those who

present more Chemistry than the entrance requirement are individually considered, but are rarely excused from college work on the basis of secondary school work.

(3) Cornell University: The entrance requirement is nearly the same as that of the College Entrance Examination Board, but the passing of this examination does not secure credit for Introductory Inorganic Chemistry in the University. The student may take an examination for advanced standing if he desires.

(3a) Columbia University: Those who pass the College Entrance Examination Board examination are admitted to a special course of lectures in Chemistry, including a somewhat advanced treatment of the subject.

(4) Syracuse University: For one year of Chemistry in a Normal School credit is given for Elementary Chemistry in college, provided the student takes another course in Chemistry and passes well. After one year of Chemistry in a secondary school, pupils are allowed to take the regular examination in Elementary Chemistry, and if they pass, credit is given for that course. If Chemistry is accepted for admission the student is admitted to second year classes, but no credit is given for Elementary Chemistry.

(5) Washington and Lee University: Students from secondary schools with the equivalent of Remsen's Briefer Course are admitted to a course including physico-chemical topics and to Qualitative Analysis. If they do well, they are excused from the former at Christmas, and continue with Analytical Chemistry; otherwise they continue the course in Inorganic Chemistry through the year. A few students from selected schools are admitted at once to Qualitative Analysis, but no college credit is given.

(6) Washington and Jefferson University: Students from a few selected schools are given credit for the first year of Chemistry in college, provided they take a later course in Chemistry, and attain a high pass record. Others are required to pass an examination before any credit is given. Chemistry is given in the Sophomore year in this institution.

(7) Wellesley College: An advanced course is provided for those students who have had a year of Chemistry. Smith's College Chemistry is used, and a somewhat exacting line of experiments is required. Some quantitative experiments, some volumetric analysis and some inorganic preparations are included.

(8) Chicago University: Students who have completed one year of Chemistry in an accredited school are admitted to special courses and complete the work preparatory for Qualitative Analysis, or elementary Organic Chemistry, in about two-thirds of the time required by beginners; that is, they complete two majors in Chemistry in place of three. The work of these two majors is carefully adapted to utilize and clarify the knowledge already gained.

(9) University of Michigan: For a year of Chemistry at an accredited school four hours of University credit are allowed (sixteen hours per semester is full credit). These students are admitted to a course somewhat less elementary than that given to beginners.

(10) University of Illinois: A full year of Chemistry in secondary school is accepted in place of one semester in the University, provided no more Chemistry is taken, (and provided Chemistry is not offered for entrance). When the student continues in chemical subjects he is advised to take the regular course of lectures in Chemistry, but spends less time in the laboratory.

(11) University of Wisconsin: Credit is given for entrance Chemistry to the extent of one or two units out of fourteen. These students enter the same classes as the others, but have a slightly different laboratory course. In the course of two months they appear to be on about the same footing as those taking the subject anew.

(12) Lehigh University: Up to two years ago certificates were accepted from secondary schools but the results were so unsatisfactory that an examination has been substituted. Those who fail take Elementary Chemistry; those who pass are admitted to a course in Theoretical Chemistry.

(13) Sheffield Scientific School: If the student passes entrance Chemistry, he is allowed to take an examination to pass off the elementary course in the Scientific School, and if successful he is admitted to Qualitative Analysis. Very few students are thus admitted.

(14) Stevens Institute of Technology: Students pass an entrance examination like that of the College Entrance Examination Board, but the instructor finds that he cannot make use of the earlier work, and all students take a course in Elementary Chemistry.

(15) Worcester Polytechnic Institute: Earlier attempts to examine upon a limited portion of elementary chemistry with the purpose of definitely eliminating this from the college course were not successful. Notebooks are now examined, and when these indicate a satisfactory course, the students are placed in separate divisions and given a different laboratory course. They attend the same course of lectures as the beginners.

(16) Massachusetts Institute of Technology: Students who have satisfied the entrance elective requirement are admitted to a special class during the first term, and the lecture and class-room instruction as well as the work in the laboratory are designed to take advantage of the work already completed by the student.

The effort is made to introduce new lines of experimentation, as well as to re-awaken interest in earlier work by encouraging the student to interpret the phenomena observed in the light of his more extended experience and with the aid of such additional concepts as have been introduced into the lectures and recitations. The two divisions of the class are united for the work of the second term.

Of these seventeen institutions one does not recognize Chemistry for entrance, two make no specific provision for students who have had chemical instruction in the preparatory schools, three provide special laboratory instruction, but give no definite college credit, six provide special instruction in both lecture room and laboratory, but without giving college

credit, while two give some college credit on certificate, and four excuse students from elementary college courses after special examination.

Such, then, is the present recognition given to chemical instruction given in schools below college grade by institutions which are sufficiently varied as to locality and type to justify the statement that they are representative. That there is a large amount of seeming duplication is easily apparent. That this results in some loss of time, energy and enthusiasm can hardly require argument. Why has this been so long tolerated and why do we not immediately take steps to avoid this apparent waste? The answer seems to me to be this: If it is at present possible to select any point in chemical instruction at which a considerable number of students, when they reach the colleges, have such a sound understanding of the facts and principles which they have been taught as to make it advisable to accept it as a foundation for further college work, this point lies so near the beginning of the college course as to make a definite excuse from this small amount of work practically meaningless.

Even those institutions which include an examination in Chemistry in their requirements for admission do not seem to find themselves distinctly better situated in this regard than those admitting students on certificate.

Some of the reasons for this state of affairs we will try to consider presently, but let us first look at the conditions as they confront the college teacher who has an earnest desire to enable his students to utilize every advantage which they have gained, recalling that in these days it is not a question of individual but of class instruction, so far as the main features of a course are concerned. Such a teacher in a college or a technical school will find pupils of each of the following types, among many more: Student A. An intelligent, reasonably thoughtful fellow from School W, where there are small classes and a helpful teacher, with a well arranged one-year course of study. With such a student one can do much. Student B. The chemical enthusiast, who has had a one-year or even two-year course with embellishments in the way of extra

hours for work by himself, or opportunities to assist his teacher. He comes from School X with high encomiums. The college teacher comes to dread the expenditure of energy and tact which is often necessary before such a student realizes that a more profound knowledge than his own may be possible; yet, after the battle is once won, perhaps half of these men make excellent students. Student C. The student who has had two years of Chemistry, in a course of ordinary excellence in School Y, under average conditions as to equipment and teaching. He feels, with some reason, that all this should count for a great deal. No argument will wholly displace this notion. He works without interest, and generally badly, and is a heavy load to carry. You ask, why not transfer him to the work of the higher years? Because experience shows that he lacks adequate preparation for it, and fails in it. Student D. An average student from an average school with a year of experience. His credentials are clear, but he has had little personal instruction and his knowledge is ill-arranged and vague, both as to fact and principle. He has no confidence in himself, and there is nothing final in his preparatory work. He is one of the most difficult cases to provide for at the start, but often turns out well in the end. Student E. A student who has spent a year, or more rarely two years under inadequate instruction, which has been worse than useless. An entrance examination would probably exclude him. Under other systems he may enter a class and it may require some weeks to discover or be sure of his trouble. His place is with those students who take up the study of Chemistry as beginners and exclusion from the more advanced class is logical, but it often works unfairly to the student and such a transfer to elementary classes when these are provided is certain to breed discontent.

But the confusion of interests does not end here! The types just referred to have been selected essentially along the lines of general efficiency of instruction and length of courses. It must further be recalled that even efficient teachers vary widely in their conceptions of the ground to be covered, and the college receives students who during the single year of

chemical instruction have had the chief emphasis laid upon descriptive Chemistry, others where it has been laid chiefly on "theoretical Chemistry," again others where the course is largely one of Physics rather than Chemistry, and finally, where considerable qualitative analysis has been included even in this brief time.

The conditions appear, then, to be these, briefly stated: Experience indicates that the pupils who have had even two years of instruction in secondary schools are in general, not in a condition to take up work in Chemistry which is more advanced than that of the first year in the college, and for students who have had but a single year there is at present so little that can be regarded as common knowledge that the present apparent duplication of work seems unavoidable. Regarding this duplication more will be said presently.

Let us next face the question, Why is it that secondary school courses have failed, and, as it seems to me, are likely to fail to serve as substitutes for any considerable amount of college instruction in Chemistry? The reasons are far from simple, and they need some analysis. We may distinguish, I think, at once between certain factors which since they are inherent in the nature of our science or in the period in the pupil's life in which the instruction is given, are common to all schools, and those elements in the situation which are the outcome of varying fitness on the part of the instructors.

Does not Chemistry itself present some peculiar difficulties? I have often heard it said that "Physics is taught in the secondary schools better than Chemistry." I am inclined to believe that it is still true as a general statement, although it may not be true of the group of teachers to whom I have the honor to speak. But may we not alter the general statement just quoted to this? "Physics is taught in the secondary schools in general better than Chemistry because physics is an easier science to teach? Notwithstanding that our every breath and thought is accompanied by chemical changes, and that we are surrounded by chemical phenomena at each moment of our lives, it is still true that the pupil in his study of chemical science, the teacher as its exponent, and the prac-

titioner whose very daily bread depends upon his success in making his associates or his superiors understand the significance and value of what he has accomplished, are one and all forced to realize that the tools used, the conditions established and studied, and the meaning of the resulting phenomena are all relatively unfamiliar and unusual, and on this very account, they are not easily comprehended. The architect builds his edifice, the civil engineer his bridge or highway, the electrical engineer his dynamo or the physicist his telescope and each has tangible evidence of accomplishment, while the chemist, after no less meritorious effort may well be obliged to depend upon a written report, or at best upon a more or less repellent and unsavory mass to secure recognition for his attainments. The beginner in Chemistry is at a similar disadvantage as compared with the beginner in Physics. In his work in Physics the pupil handles, for example, the balance, the mirror, the pendulum, or the battery, and he makes his measurements in units which are largely familiar to him; and the phenomena which he observes are not foreign to his daily life. On the other hand the very test tube and beaker to which the student of Chemistry is immediately introduced are unaccustomed objects, the bottle of acid is still more so, and we often accentuate the situation by asking him to don breast plate and armor for his personal protection, in the shape of aprons or rubber sleeves. While on the one hand the concepts and laws of Physics may not be properly alluded to as "easy" yet it seems to me evident that they make less demands upon the intellect and the imagination than the fundamental principles of Chemistry, if these principles are to mean more to the pupil than mere memorized statements.

With the growth of the holes in the pupil's clothing the strangeness of the beaker, test-tube and acid bottle lessens to be sure, but he is coincidently introduced to increasingly complicated phenomena; he is asked to conceive of molecules, atoms, ions, even of electrons (by the more misguided instructor); he is asked to form some notion of valence, to construct chemical equations, and to "state all that they express"—a thing which you and I with our greater wisdom and experience may

well hesitate to attempt. He must master the principles of stoichiometry, that branch of chemical science which seems to baffle the human intellect to a degree that never ceases to amaze even experienced teachers. It may even happen that his course includes such concepts as those of chemical equilibrium, the mass law, or the phase rule which, in their relation to the proper subject matter of a secondary school course, somehow remind one of the records of those early chemical processes found in the first chapter of Genesis in which it is quite incidentally stated that near the close of the fourth day the Lord created "the stars also." It is easier to forgive the ancient recorder for his lack of a due sense of proportion, than to excuse the twentieth century instructor.

This leads me to my second question: Is it not actually unreasonable to ask the average young boy or girl at seventeen or eighteen, to gain in one year a real insight into chemical science? I believe that it is, and that the most that one can hope to actually accomplish is to broaden his horizon by acquainting him with the interpretation of certain common phenomena in the terms of Chemistry, giving him only the simplest fundamental principles to help him to understand these terms, and leaving him to learn the meaning of the more abstract conceptions after a year or two of greater maturity, if he attends a college or, by later thoughtful reading, if he is not a college man, but has an inquiring mind. I cannot avoid the conviction that we have ignored for too much and too long the disparity between the immaturity of the pupil and the nature of the demands made upon him by chemical science. I think this is the more true in these days when it seems evident that our educational system, through its multiplicity of subjects and the over-prominence of the baneful influence of the examination paper, tends to remove nearly all opportunity for concentrated or independent thought on the part of the pupil, or of originality in methods of instruction on the part of the teacher.

I believe, then, that even the competent teacher, with adequate equipment and the usual time allotment must find great difficulty in teaching Chemistry even to the more recep-

tive pupils at the secondary school age so thoroughly as to permit the college to substitute it for any appreciable part of the college course, at least under present conditions. For, let it be said with all humility, we college teachers too often make a sad mess of it even with the advantages as to maturity and environment, which we presumably possess.

The statement is sometimes made by college teachers that they would prefer to receive students without previous chemical experience, and the question may be raised whether or not it would be better to abandon entrance requirements in Chemistry. I believe it is the opinion of the majority of college teachers, especially those who have given the problem the most careful thought that this would be very unfortunate. I should consider it so for at least two important reasons: first, because, while formal excuse from a definite portion of the college work is not yet generally practicable, the experience already acquired by the student can be made very helpful if judiciously utilized, and, second, because it is only through increased encouragement and cooperation between the schools and the colleges that better results can be hoped for.

It is noticeable in the statements already quoted regarding the present practice in the various institutions that the State colleges are apparently giving a greater amount of definite credit for work in the secondary school than the others. This is frankly stated by some of the college teachers to be due to the closer organic connection of the state university with the general school system, and is admittedly done under slight pressure. On the other hand, these institutions have, through the system of school inspection on the part of the state universities, a more direct means of influencing instruction in the preparatory schools. The outlook for better conditions in the future is generally regarded as favorable.

Perhaps we may ask just here,—What would these better conditions be like? It is probably fair to say that they would be such as to avoid duplication of work. Obviously repetition and duplication should be reduced to a minimum, and no one would welcome changes which tend to bring this about more than I. But I think it is possibly true that there is less actual

duplication of work than is commonly supposed in those institutions in which the students who have had a year or more of chemical instruction are segregated in separate divisions. Let us take a concrete case by way of illustration. The pupil in the secondary school prepares chlorine, using salt, sulphuric acid and manganese dioxide, or hydrochloric acid and manganese dioxide. The time available rarely permits the use of any other method, and the chemical changes involved are sufficiently complex to present some little difficulty for their complete comprehension. Few pupils, as experience shows, really understand that this is a typical, and not an isolated or unique procedure, and the role played by the manganese dioxide is but vaguely grasped. It is true that such students are asked to again prepare chlorine from these materials, in the college laboratory, but they are at the same time required to study the action upon hydrochloric acid of such agents as lead dioxide, barium dioxide, hydrogen dioxide, potassium permanganate or potassium dichromate, and to discuss the changes involved from the common point of view of the oxidation of the acid, and the actual proportion of duplication of work is really small. Similarly, in the study of the action of acids upon metals, while it is desirable to ask the student for the sake of completeness to repeat the familiar process for the production of hydrogen from zinc and sulphuric acid, this becomes a mere incident in the series of experiments and in the broader discussion of all phenomena observed, which may well go so far as to include the principles of solution tension, in the case of such students.

It is, apparently, work of this general character which many college teachers are offering to those who have had earlier training. The laboratory work is, as we have seen, frequently accompanied by lecture demonstration and recitations of a corresponding grade, and while it does not, of course, appeal to the student as a step in advance as would some other procedure which seemed to give a stamp of finality to his earlier studies, it may well be questioned whether it does not better foster his intellectual welfare than the more alluring

plan could do. It should, however, be the purpose of the college teacher to keep closely in touch with the actual, and probably increasing average attainments of the pupils sent to him, in order that he may take all proper advantage of the instruction already given, and it is probably true that a larger number of institutions should offer such moderately advanced courses than is at present the case.

I propose next to refer briefly to one or two specific points at which it appears to me that the instruction in the secondary schools might be improved. I do this with much hesitation for I realize that these very details or methods which perhaps fail to appeal to me may well be very dear to another, and I realize that I should be loath indeed to have the actual efficiency of my own instruction judged by certain alleged quotations on the part of some of my students, or even by the subsequent acts of many of them. A conspicuous instance of the failure of some of our hopes was afforded by a statement made by one of our students in a recent written test that "nitroglycerine is used as a lubricant."

A question which many find difficult to answer is this: How far, taking into account existing and not idealized conditions, is it just to regard note books as an index of the efficiency of the instruction as given in a particular school, or college? I shall not be rash enough to undertake to answer this beyond expressing a conviction that while a note book which is well-kept and carefully corrected probably indicates careful, efficient teaching, a relatively poor note book may represent more accurately an overburdened condition of the teacher, which prevents adequate inspection and correction, than actual inefficiency in instruction. For it is often true that much of apparent error in the records may have been actually corrected in conference or class-room. This does not however apply to some of the atrociously bad specimens which are occasionally met with, nor, on the other hand does it ignore those note books which are obviously not records of work done, but studiedly prepared exhibits, executed through

connivance of teacher and pupil to delude the unwary, and at the expense of the fundamental principle of all scientific work, rigid honesty.

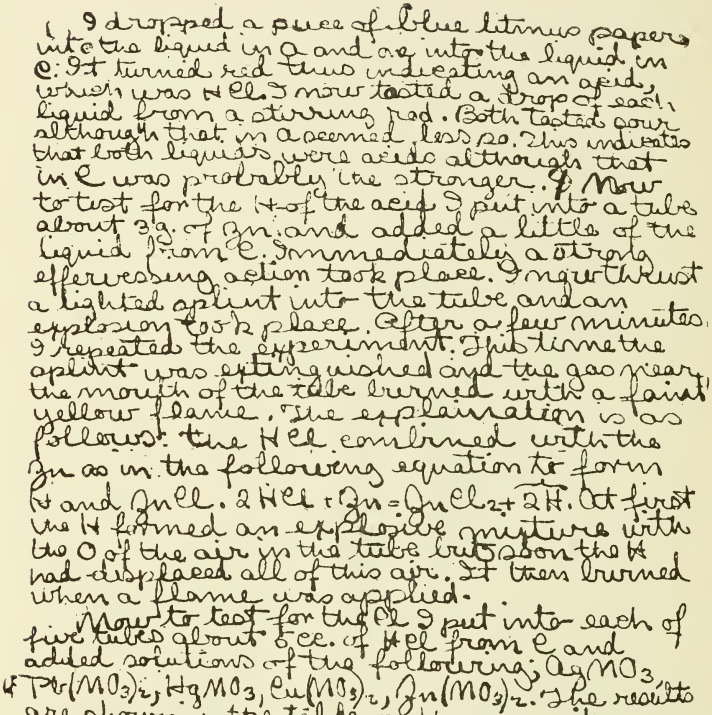
In general, it seems to me that there is far too much of a tendency on the part of both teacher and pupil to regard each experiment as a thing apart; something to be done and forgotten. Too many teachers are contented to have their students perfunctorily perform the magic "forty experiments" which *some one else* has prescribed for them, rather than to devise twenty-five, fifty-five, or any other number of their own to illustrate the facts or principles which *they* desire to drive home, and to see that these are discerned by the pupil. This attitude is reflected in many instances in the notes submitted, which are long, and minutely descriptive of really insignificant details, but miss the real point of the experiment. This, in turn, comes from the fact that the pupil is not sufficiently informed why he is asked to perform the experiment at all, and in the strangeness of the work he naturally confuses the important and the unimportant. For example, he is often apparently left to think that a description of "the apparatus used" is as essential when he pours silver nitrate solution from a bottle into a test tube containing a halide solution, as when he is preparing nitric acid from saltpeter, and he elaborates his descriptions, with the same fidelity in the former case as in the latter, with a very considerable aggregate loss of good energy on his part and that of his instructor. But that is not the worst of it, for he gains an idea that all experiments are to be treated with similar uniformity in other respects, even including his search for their hidden meanings. I do not of course advocate telling the student what is to happen and then asking him to say that it did occur, adding, possibly, the color of a precipitate; but I do believe that a great deal would be gained if nearly all experiments, or groups of experiments, were prefaced in the laboratory directions by a brief statement regarding the principles or typical changes involved, and if, then, the student were encouraged to make his observations with reference to these statements and were required to show

that he understands how the given experiment actually confirms the points in question. This would do much to avoid what is at present a wasteful expenditure of time, muscular energy and eyesight—all of which could be used to increase the pupil's experience, and it would partially, at least, eliminate the vague groping which results as those appalling scientific monstrosities which follow the words "I conclude" in the note book of many a conscientious student who has undergone almost a brain-storm in their production. Have you ever recalled the bewilderment of your student days, when you had no idea what to look at among so many phenomena? Have you ever taken a half-dozen experiments and candidly asked yourself what *you can legitimately conclude* from what has been performed? It is very much like trying to answer some of one's own well-sounding examination questions, a procedure which often causes them to lose their attractiveness.

My query, then, is this: Do we not tend to lay too much stress upon mere performance of experiments, and devote too much time to the making and reading of descriptive notes which are often copies of the experiment manual, and too little time to helping the pupil, through judicious suggestion regarding the experiments and through questioning at the work-table and in the recitation room, to comprehend what it is all about, and the relation of a given experiment to others already performed?

In order that the perplexities of the college instructor may be brought more clearly to your minds, and in order to illustrate certain types of note-books, I have reproduced a few pages from the books presented in connection with the entrance elective requirement of the Massachusetts Institute of Technology. The first (Fig. 1) is a representative of a rather small number of superior books. The observations are carefully recorded, the deductions are valid and well expressed and there is evidence (not shown in the cut) that the note-book had been inspected and corrected. Under existing con-

ditions as to numbers of pupils to be taught it is probably too much to expect that all will attain a standard which this note-



I dropped a piece of blue litmus paper into the liquid in A and one into the liquid in C. It turned red thus indicating an acid, which was HCl. I now tasted a drop of each liquid from a stirring rod. Both tasted sour although that in A seemed less so. This indicates that both liquids were acids although that in C was probably the stronger. Now to test for the H of the acid I put into a tube about 3 g. of Zn and added a little of the liquid from C. Immediately a strong effervescing action took place. I now thrust a lighted splint into the tube and an explosion took place. After a few minutes I repeated the experiment. This time the splint was extinguished and the gas near the mouth of the tube burned with a faint yellow flame. The explanation is as follows: the HCl combined with the Zn as in the following equation to form H and $ZnCl_2$. $2HCl + Zn = ZnCl_2 + 2H$. At first the H formed an explosive mixture with the O of the air in the tube but soon the H had displaced all of this air. It then burned when a flame was applied.

Now to test for the Cl I put into each of five tubes about 5 cc. of HCl from C and added solutions of the following: $AgNO_3$, $Pb(NO_3)_2$, $HgNO_3$, $Cu(NO_3)_2$, $Zn(NO_3)_2$. The results are shown in the table on the opposite page. As the chlorids of Ag, Pb and Hg are known to be insoluble while those of Cu and Zn are soluble this test shows Cl to be present.

Experiment 38 shows that H_2S is a colorless gas and that it is soluble in water. It has a very disagreeable odor and seems to be heavier than air. It has a strong affinity for most metals and for

Fig. 1

book appears to represent. To all appearances the records are original and the instruction efficient.

The pages reproduced in figures 2 and 3 are of a not uncommon type. The first leaves one in doubt as to what part of the work has been performed by the pupil, since the state-

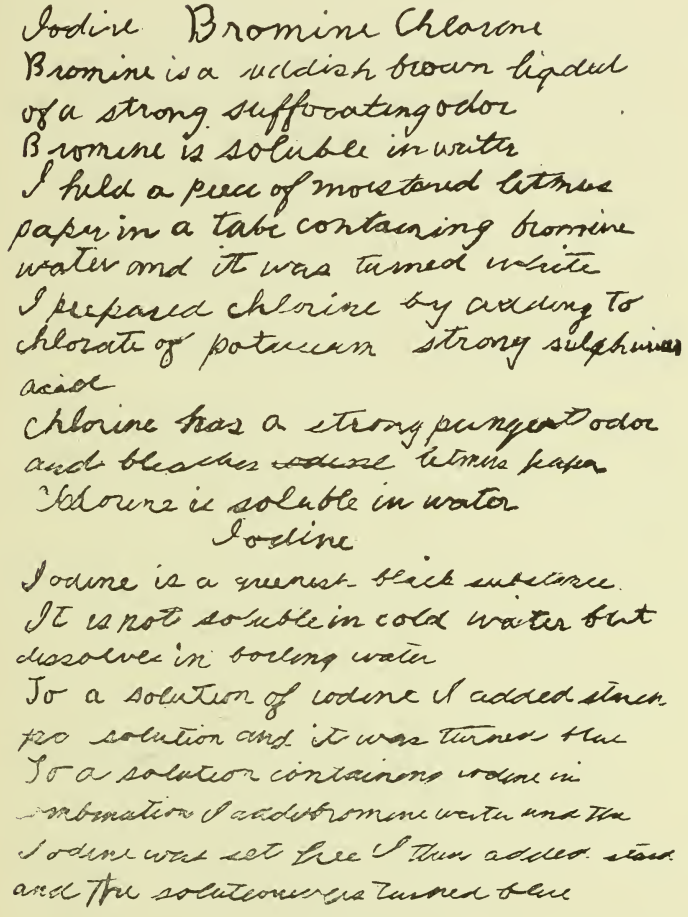

Iodine Bromine Chlorine
Bromine is a reddish brown liquid
of a strong suffocating odor
Bromine is soluble in water
I held a piece of moistened litmus
paper in a tube containing bromine
water and it was turned white
I prepared chlorine by adding to
chlorate of potassium strong sulphuric
acid
Chlorine has a strong pungent odor
and bleaches iodine litmus paper
Chlorine is soluble in water
Iodine
Iodine is a greyish black substance
It is not soluble in cold water but
dissolves in boiling water
To a solution of iodine I added starch
pro solution and it was turned blue
To a solution containing iodine in
combination I add bromine water and the
Iodine was set free I then added starch
and the solution was turned blue

Fig. 2

ments made regarding the physical properties could have been copied from a book, the records of experiments performed are distinctly wrong and the case of the alleged preparation of

chlorine would, if ever followed, lead more directly to a residence at a hospital than to any worthy scientific end. Fig-

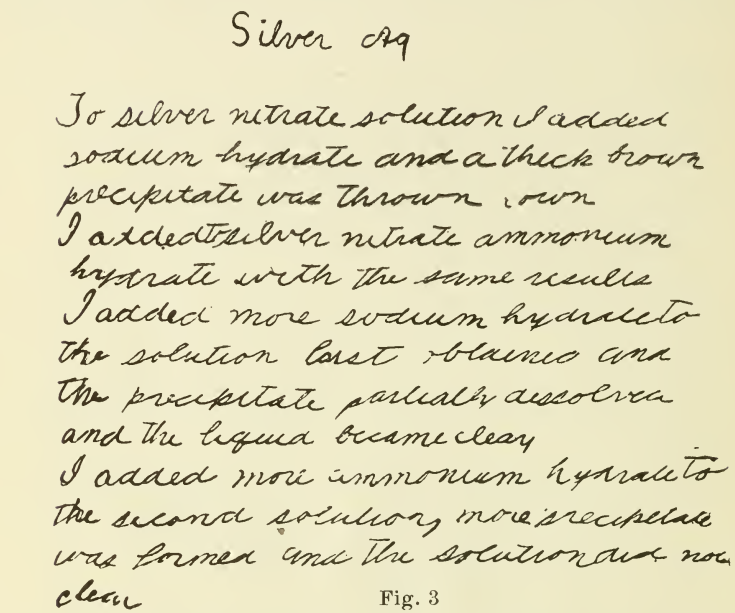

Silver Nq
To silver nitrate solution I added
sodium hydrate and a thick brown
precipitate was thrown down
I added to silver nitrate ammonium
hydrate with the same results
I added more sodium hydrate to
the solution first obtained and
the precipitate partially dissolved
and the liquid became clear
I added more ammonium hydrate to
the second solution, more precipitate
was formed and the solution was not
clear

Fig. 3

ure 3 shows a page which makes no pretense of being anything more than a mere record of a useless mixing of a few

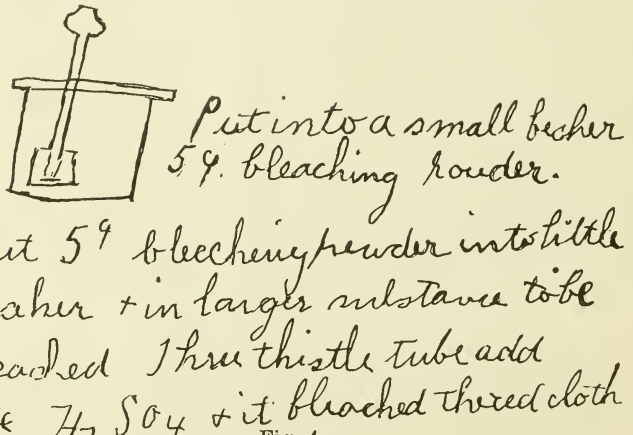

Put into a small beaker
5 g. bleaching powder.
Put 5g bleeching powder into little
beaker + in larger substance to be
bleached Thru thistle tube add
5 c H_2SO_4 + it bleached thread cloth

Fig. 4

solutions, and moreover these records are also entirely wrong.

The two pages just commented upon did not bear any evidence of inspection on the part of the teacher; that shown in figure 4 bore the stamped legend "approved," but a careful inspection leaves one in doubt as to what particular feature of the record warranted this, unless it may be the evidence of sympathy (?) on the part of the pupil with the tendency towards spelling reform.

These are not exceptional pages; they are representatives of many that pass under our inspection each year, and I ask you, with all sympathy for the teachers concerned, what evidence does any but the first give that one may safely omit a review of the ground supposed to be covered by this work in a college course which is primarily expected to furnish a safe foundation on which there is afterwards to be erected a very considerable superstructure of chemical knowledge? Are we not justified in our perplexities!

I should like also to appeal to the teachers in the preparatory schools to encourage the pupils to better economize their laboratory time. Too many are allowed to placidly watch a crucible heat, or a solution boil, when other experiments might be in progress at the same time, and these habits are difficult to overcome. I should like to suggest too, that some of the most promising pupils are often seriously harmed by allowing them to work too much by themselves, or by encouraging them to go beyond their depth in a particular line in which they appear to be specially interested to the detriment of their fundamental work. Such pupils usually come to college with an exaggerated sense of their own attainments and it frequently requires long and tactful persuasion on the part of the college instructor before they can be reduced to reasonable humility.

On the other hand I venture to plead that all proper encouragement shall be given to pupils to take advantage of such special privileges as the colleges offer. It is not an infrequent occurrence to find a pupil who tells us that he has

been advised by his teacher to take the elementary course for beginners as one in which he will incur less risk of failure. Were the examination the goal of the course, there obviously would be little to criticise in this suggestion; its effect upon the student as an embryo scientist is seldom happy.

In conclusion let us ask, how we can make the work in Chemistry in the various institutions mutually helpful?

First, perhaps by a more extensive cooperation on the part of the colleges and technical schools in the way of separate courses for those who have taken Chemistry before entrance, a closer study of the problem on the part of all, and a readiness to recognize improved conditions.

Second. By an intelligent delimitation of the secondary school course, so that it will only offer what the pupil can best assimulate at the age and in the environment in which he works. This is too large a topic for discussion in this connection, and it is sadly complicated by the necessity for furnishing a course which shall be alike useful for the pupil who expects to enjoy college opportunities and his less fortunate associate. I plead, as I have often plead, for a course which is fundamentally descriptive in its character. I do not mean a mere catalogue of facts, but a course in which selected facts are taught for some specific reason, which is invariably explained to the pupil, and in which these facts are interpreted for him in terms of the simplest of the fundamental principles and concepts, so often repeated and constantly utilized that they may ultimately mean more than memorized paragraphs from what he may later remember as "a book with a green cover." I think there can be no greater mistake than to suppose that such a course is a less worthy one than such as is often pointed to with pride as a "theoretical course" and no teacher should consider that it will demand less than his best efforts, supplemented by all his knowledge, to utilize the opportunities for helpful, and thorough instruction which such a course affords. It is, of course, difficult to determine whether the instruction of the boy or girl destined for college should be differentiated from that of their fellow-students, and, if so,

at what point, but I venture to hope that a decision may yet be reached, through coöperation, which may permit us to select a limited field which shall be so well covered as not to necessitate repetition in college, and that this may be done without prejudice to the candidate or non-candidate for college credits. How soon this will come, or how large this field may be, I do not venture to predict.

A third gain, would, it seems to me, be found in the increasing of the time allotted to Chemistry, in the secondary schools. I do not believe that it is now commensurate with either the difficulty or dignity of the subject, and while I have not wholly reliable data on which to base an accurate conclusion I venture to suggest that an increase of perhaps a third more time should be asked for in the interests of all, and especially those who will not have opportunity to pursue their studies further. While such an increase might not enable the colleges to substitute this work for entire college courses it would hasten the time when a definite point of articulation, as suggested a moment ago could be found.

Finally, there is urgent need of decreasing the demands made upon the teacher of Chemistry in the secondary school for duties other than those of instruction, and also a critical need for relatively more instructors. I believe that a very large proportion of the unsatisfactory results now noticeable are due to the fact that in most of our schools it is not humanly possible for the teaching force to accomplish what should be expected of them or to be at the desk of the pupil when he reasonably needs assistance. In some schools which have come under my observation the distribution of supplies must be attended to by the senior (or often the only) instructor, an operation which consumes a half hour or more. Probably no science demands for its understanding by the beginner more individual instruction in laboratory and class-room than Chemistry, and the school authorities should realize this. When they do we shall have much cause for rejoicing, and the present groping and bewilderment on the part of the young student will in part at least give place to enjoyment in the

study of a science which is really second to none in its attractiveness or value when pursued under favorable conditions.

It is a pleasure, in closing, to say that I feel that too much praise can hardly be given to the loyal, hard-working, intelligent and inspiring teachers who are accomplishing so much in behalf of our science in the training of the beginners. No thoughtful college teacher can fail to recognize the good work done in very many schools throughout the country, and while we feel that more definite recognition in the college curriculum cannot wisely be given to this work at the present time, I am sure from the messages which have recently come to me from many colleagues in many institutions that there is an increasing appreciation of the fact that the way to better things lies through a sympathetic appreciation of our common problem and our common difficulties.

Luncheon was served by the young ladies of the Domestic Science Department of Simmons College. This was arranged for by Prof. James F. Norris, and it was appreciated by all present.

After luncheon the members of the Association proceeded to the Lowell Building for the afternoon lecture.

LECTURE ON DESTRUCTIVE DISTILLATION

By Prof. F. H. Thorp

The manner in which the elements are combined in many organic substances found in Nature, is not known, and analysis shows only the proportion in which the several elements are present. It is reasonably certain, however, that most of these substances contain very complex molecules. When heated in the presence of air, the readily oxidizable elements, such as carbon, hydrogen, sulphur, etc., are burned, as in the ordinary process of combustion. But the action of heat in the absence of oxygen, may bring about merely vaporization of the body, or a more or less extensive decomposition of the complex

molecules composing it. This latter condition is what prevails in the process known as Destructive Distillation.

The **Destructive** or **Dry Distillation** of a substance, then, consists in decomposing it by heating in a closed retort, with exclusion of air, (i. e., of oxygen) in such a manner that products are obtained which are not present as such in the original material.

By simple distillation, a body is vaporized and recovered, chemically unchanged, as it existed before the operation, by condensing the vapor. This might be termed **Eductive Distillation.** But in destructive distillation, the resulting substances are always different in their chemical and physical properties, from the original one, and they are formed by chemical changes in the original molecule. As a rule, these changes are very complex and obscure, and the products are subject to more or less variation, according to the conditions prevailing in the retort.

In general, destructive distillation involves the breaking up of molecules of large size, and the formation of several bodies having simpler molecular structure and lower molecular weight; but it is also possible that during the rearrangements small amounts of substances more complex than the original one, may be produced by polymerization.

The so-called "Cracking" which takes place during the distillation of heavy petroleum oils, and other hydrocarbons of high molecular weight, is merely a phenomenon of destructive distillation and is the direct result of the high temperature employed. This might be represented by chemical equations in some cases, although the process is doubtless more complicated than these simple equations would indicate. Assuming that the hydrocarbon C^{15} H^{32} having a boiling point of 271°C., is distilled under atmospheric pressure, it might, in part, break up according to either or both of the following ways:—

$$\underset{}{C_{15}H_{32}} = \underset{(B.\ P.\ 37^{0})}{C_5H_{12}} + \underset{(B.\ P.\ 150^{0})}{C_9H_{20}} + C \qquad \text{or}$$

$$\underset{}{C_{15}H_{32}} = \underset{(B.\ P.\ 70^{0})}{C_6H_{12}} + \underset{(B.\ P.\ 122^{0})}{C_8H_{16}} + CH_4$$

Thus it is necessary, in carrying on the simple distillation of bodies, of heavy molecular weight, to use special precautions, chiefly with the view to lowering the temperature of the distillation, for example by the use of vacuum stills, or by the introduction of free steam directly into the liquid in the retort.

Most of the complex organic substances, especially solid bodies, cannot be heated to any considerable degree, without decomposition ensuing. So starches, sugars, cellulose, resins, bitumen, albuminoids, fats, waxes, etc., are thus decomposed, yielding gases, liquids and a solid residue of carbon and mineral matter. The nature of these first, crude products, varies, of course, according to the material used. The gases usually consist of compounds of carbon and hydrogen or oxygen, of ammonia, cyanogen, hydrogen sulphide and carbon disulphide. The liquids consist of aqueous distillates and heavy, oily masses of tar.

When complex organic substances are destructively distilled the decomposition is, to some extent, cumulative, and certain stages may be recognized, at which characteristic products are given off, although both liquids and gases are produced, more or less, throughout the entire process. At low temperatures, the products are largely straight chain compounds, while at higher temperatures, compounds containing ring structures are more in evidence; but at very high temperatures, the aromatic bodies are themselves largely decomposed in the retort, and the ultimate products are then mainly gases, such as methane, hydrogen and carbon monoxide.

During the early stages, of a distillation, when there is usually considerable oxygen present in the material, the gas evolved contains much carbon dioxide; but during the later stages, when the oxygen has been largely removed, carbon monoxide becomes more prominent. Following this, hydrocarbon gases, such as benzene, ethylene, acetylene, and methane predominate; and lastly, hydrogen, probably due in part, at least, to the decomposition of the hydrocarbons, in the presence of the hot coke, and to the influence of the walls of the

retort itself. The reactions* representing these changes can be indicated as follows:—

$$3C_2H_4 = 2C_2H_2 + 2CH_4$$
$$4C_2H_4 = 2C_2H_2 + 3CH_4 + C$$
$$2CH_4 = C_2H_2 + H_2$$
$$CH_4 = C + 4H$$

The liquid products of destructive distillation consist of an aqueous or water soluble part, which comes over mainly while the temperature is under 275°C., and the so-called "tar," or oily, insoluble portion, which comes over at rather high temperatures. The aqueous liquor may be strongly acid in some cases, as in wood or resin distillation, or it may be basic, as in the distillation of coal, shale and bones. The important industrial examples of these aqueous distillates are the pyroligneous acid of wood distillation, and the ammoniacal liquor of coal distillation. Tar is the general name given to the liquid distillate which is heavier than and mostly insoluble in water. It is of exceedingly variable and complex composition, though in all probability, many of the substances derived directly from tar, are not present as such, in it, but are produced by decomposition of constituents of the tar. Tar from certain sources is characterized by the presence of notable amounts of particular substances:—thus hard-wood-tar is rich in cresols, guaiacol, creosols, etc.; coniferous wood-tar yields terpenes, in addition to some of the above. Coal-tar is generally poorer in the oxygenated products, contains more solid hydrocarbons, such as naphthalene and anthracene, and very little or no free acids. Lignite tars contain notable amounts of unsaturated hydrocarbons, sulphur compounds, and nitrogenous substances. Bone-tar yields pyrrol and pyridine bases in large quantity. All tars contain more or less free carbon in very fine state of division.

In all destructive distillation, if the process has been carried to a point at which practically all the volatile matter has

*Harper, Utilization of Wood Waste by Distillation.

been expelled, a residue is left in the still, consisting of carbon and the mineral constituents of the original substance. This residue is **charcoal** or **coke.**

Destructive distillation is practiced by man, by the rapid application of high temperature to the material. But very similar results are accomplished by Nature, through the application of low temperatures, aided by great pressure, during long periods of time. This has already been shown in the gradual transition, in the earth's strata, of vegetable matter, through the successive stages of peat, lignite, coal, to anthracite. The formation of petroleum, asphaltum, and bitumen, is also to be attributed to a similar natural destructive distillation of organic substances within the earth's crust. In these instances, time has replaced intensity during the heating.

The materials employed for destructive distillation on a large scale, and which are thus the foundation of individual industries, are **wood, coal, shale, bones, peat, resins, garbage, and various refuse materials.** Sometimes **petroleum** distillation is classed among the destructive distillation industries, but this needs qualification. Petroleum is itself most probably a product of natural destructive distillation, and with a few exceptions, only fractional distillation is desired in the refining of crude oil. But when "cracking" occurs, there is destructive distillation, in addition to the fractionation. By this means, a larger yield of the more valuable, burning oils is obtained, at the cost of some of the less valuable, heavy oils.

The refining distillation of shale-oil, and of tars, can also be classed with that of petroleum; some cracking always occurs with these materials, especially if the distillation is pushed to the extreme, to obtain all the volatile matter possible. There is always a residue of coke in the stills at the end of such a process.

Some common organic materials are produced by dry distillation of relatively simple substances; thus acetone is made on the commercial scale, by distilling calcium acetate; and acetamide by distilling ammonium acetate.

The apparatus used in any destructive distillation, may be

grouped in two general classes: (a), those in which the volatile products are wasted, and nothing but the solid residue of charcoal or coke is recovered; such for instance, are the ancient charcoal heap, the bee-hive coke oven, and certain types of garbage and refuse destructors. (b), Those in which part, at least, of the volatile products are saved, as is the case with modern charcoal kilns, the by-product coke-oven, and the retorts for the distillation of shale, and for the preparation of coal-gas.

Apparatus of the first class represents the primitive stage of the industry, but is, unfortunately, largely employed today. Even the yield of charcoal or coke obtained, is less than it should be; the idea that the quality is superior to that from the by-product plants, has been pretty generally discredited. That apparatus of this kind is cheaper to build than is the more complicated plant for saving the volatile products, must be admitted, and it is also true that the location of some of these plants with reference to a market, for the by-products, is unfavorable. But in many cases, economy would result from a change to modern apparatus, and an improved method of working. The charcoal heap and the bee-hive coke oven, are relics of antiquity which should be tolerated no longer.

Apparatus of the second class, in which recovery of the volatile products is intended, must consist of a retort or kiln in which the material is heated, a condenser for liquifying the condensable vapors, and suitable collecting or storage tanks to receive the various crude distillates. Traps and pipes are usually provided also, to collect and carry off the non-condensable gases. The yield of by-products obtained is very much influenced by the form and material of the apparatus, as is also the expense of repairs and cost of labor.

The size and working of the condenser is exceedingly important since any vapors passing through it uncondensed, will either be lost or increase the cost of treating the gases.

The **retorts** are usually made of brick, fire-clay or iron, and may be arranged for hand charging or mechanical charging. Cast-iron retorts are very liable to crack, but are not

so rapidly burned out as are those of boiler plate. But the latter are thinner walled and can be more easily repaired than cast-iron. They may also be made of much larger size. It is very essential that the retort be gas-tight and it is customary to lute the doors and man-hole covers with wet clay or other cement, to prevent leakage. Owing to the high temperatures employed, those types of retorts which are cooled down between charges, suffer rapid deterioration, and repairs become a considerable item of expense. Retorts which can be charged and discharged without cooling, are generally the most economical of fuel, labor and upkeep costs.

The character of the distillation is much affected by the size of the retort. Small retorts give a quick heat, and, from a given weight of material, a somewhat larger yield of gas, richer in hydrocarbons, such as ethane, ethylene, acetylene, etc.; but the charcoal or coke produced is generally very porous and soft. Larger retorts yield less gas, of a lower illuminating power, but produce more liquid distillate and a harder coke.

Condensers are usually made of iron or copper;—the former for substances of neutral or basic character, such as are obtained from coal or shale; the latter for acid distillates, such as those from wood, peat and resins. They are usually water-cooled, though in certain cases, as in the manufacture of illuminating gas, air cooling is preferred. When water cooled, the flow of water is sometimes stopped, during the last part of the distillation, in order that the thick, viscous tar may not congeal in the tubes of the condenser.

The shapes of the condensers vary considerably, but in general, straight tubes, inclined or vertical, are used. The tubes should not be too small, seldom less than two inches diameter, and at least six or eight feet long. Small condensers require more rapid flow of the cooling water; generally, a large condenser, with a slower flow of water, is cheaper. Worm condensers are not advisable, owing to the difficulty of cleaning, in case the tarry products should adhere and solidify in the tubes.

The destructive distillation of wood is a very old industry, practiced chiefly to obtain charcoal, and even today, the ancient and wasteful method of making charcoal in heaps, is extensively used. This wastes all the volatile products and part of the charcoal itself is destroyed, only about 25 per cent. of the weight of the wood being recovered as charcoal. The heaps, consisting of circular piles of cord-wood around a central flue, are 30 feet or more in diameter and 8 to 10 feet high. They are covered with sods and turf, well beaten down to exclude the air. The wood is ignited at the central flue, and air is admitted through passages around the outer edge. Some of the wood undergoes a smouldering combustion, which furnishes heat for the carbonizing of the remainder. By opening new air-holes and closing the old ones, the fire is gradually spread through the whole pile, which requires from seven days to two weeks, according to circumstances. The color of the smoke escaping from the heap, guides the attendant, and when this becomes thin and blue, the draught is entirely cut off, and the fire extinguished by lack of air.

Modern retort distillation of wood saves the volatile products and gives a larger yield of charcoal. Both hard and soft woods are thus distilled, and in the latter case, superheated steam is frequently used to distill off turpentine and resins, before the actual decomposition of the wood tissue occurs. A considerable amount of resinous pine and fir is thus distilled, and much wood turpentine (sample) is obtained. The rapidity and degree of heating affects the yield of the product considerably. Small retorts, heated very slowly, and thus at a low temperature for a long time, yield the most pyroligneous acid and tar. Rapid heating and high temperatures reduce the liquid products and increase the gases. Large retorts are rather difficult to heat uniformly, and the wood in the centre is liable to be imperfectly carbonized. Furthermore, the vapors remain too long in contact with the hot walls of the retort, and considerable decomposition, or cracking may occur.

Beech, maple, birch and oak are the hard woods generally used. Above 160°C. and under 275°C., a thin, watery dis-

tillate, the **pyroligneous acid,** is chiefly produced. Above 275°C., the gaseous products become noticable and finally, the tar distillate is most abundant between 350 and 450°C. The usual time of one distillation ranges from 12 to 24 hours. The charcoal, when drawn hot from the retort, is put into a tight iron box, and allowed to cool with exclusion of air.

The yield of products is of course, variable, according to the conditions prevailing. According to Ost, from 396 Kg. of beech wood, the following yield is obtained:—

122 Kg. of charcoal.

157 Kg. pyroligneous acid.

24 Kg. wood-tar.

93 Kg. gases.

The gases are high in carbon dioxide and low in illuminants and so are not of use for lighting. They have much heat value, however, and are burned under the retorts.

The charcoal is sold as one of the chief products. The tar is often burned under the retorts, unless the plant is near to a market, in which case, it is distilled into "light oils," "heavy oil" and pitch which crude products are sent to the refiners.

The pyroligneous acid is usually subjected to a rough separation into crude wood alcohol and acetic acid derivatives, especially calcium acetate. To separate the tar and empyreumatic bodies, dissolved in it, the pyroligneous acid is distilled and the vapors pass through tanks containing milk of lime. This removes the acids and phenols, and saponifies the esters, leaving the vapors of methyl alcohol, acetone, water, etc., to pass into the condensers; this yields a distillate of about 50 per cent. methyl alcohol, which is again distilled in a rectifying apparatus, raising the concentration to 80 or 82 per cent. The product then goes to market as crude wood alcohol. The yield is about 10 gallons per cord of hard wood.

The solution of calcium acetate produced by the neutralization of the acid vapors from the pyroligneous acid, is evaporated to dryness; any tar which rises during the evaporation is removed by skimming. The dry calcium acetate is sent to

market as "gray acetate of lime." About 190 lbs. of 80 per cent. purity, is obtained from one cord of hard wood. It is the raw material for the manufacture of commercial acetic acid and acetates.

Sawdust, shavings, extracted dye-wood chips, spent tan-bark, and other forms of woody refuse, are sometimes distilled in special forms of apparatus, but are of relatively small importance.

The destructive distillation of **Coal** may be viewed from two points, according as coke, or gas is to be the major product. The former has been discussed under the subject of fuels; the latter will be taken up in connection with gas-making.

When coal is distilled in the bee-hive oven, nothing is secured but the coke. The heat evolved by the combustion of part of the charge, is sufficient to produce coke from the remainder. The cost of building and upkeep of the by-product oven, is greater, but it saves the gas, tar, and ammoniacal liquor, and gives a large yield of coke. If favorably situated as to a market for the by-products, it is more profitable.

The temperature necessary to decompose coal is much higher than for wood, and hence coal-tar contains more of the aromatic substances than wood distillates, which are largely of the aliphatic series. Since coal contains a relatively small amount of oxygen, the gases evolved are rich in "illuminants," and relatively free from carbon dioxide. Distilled at moderate temperatures, as in the ordinary retort, coal yields gases rich in benzene, ethane, ethylene and acetylene. These constitute the illuminants of the coal-gas, but if the retort is very hot, 1000° C., or over, they decompose to methane, hydrogen and free carbon, and the luminosity of the gas is reduced. Hydrogen, methane and carbon monoxide are always present in large amounts and furnish the heat necessary to cause incandescence of the carbon liberated during the combustion of the illuminants. The coke produced at high temperature is harder and better than that made at lower heat.

Nitrogen present in the coal, appears in part, among the

gases as ammonia and its compounds. These dissolve in the scrubber waters, which thus have a very strongly alkaline character.

The tar, or oily distillate, is a very complex mixture, and varies according to the shape and size of the retort, the temperature, and the kind of raw coal used. The yield averages 4 to 6 per cent. of the weight of the coal. When the plant is near a market, the tar may have considerable value, but often it is burned to utilize its heat value, and to get rid of it.

Tar produced in coke ovens differs somewhat from that made in the ordinary gas process. **Gas-tar** is generally richer in the light oils (benzols), which are the more valuable constituents, and contains paraffine and olefine oils, and solids. There are always oxygenated substances (as cresols and guaiacol), present to a considerable extent.

Coke-oven tar, being produced at high temperatures, contains fewer paraffines, but more aromatic substances, such as naphthalene, anthracene, chrysene, phenanthrene, and the oxygenated substances are largely represented by phenol, (carbolic acid). There is also more free carbon.

The prevailing differences between the two varieties of tar, are shown by the following analyses, as given by Ost:—

	Gas-tar.	Coke-oven tar.
Light benzoles,	1.5 — 2. %	0.1 — 0.5 %
Heavy "	0.5 — 1.	0.5 — 1.0
Carbolic acid, (pure)	0.5 — 1.	0.5 — 1.
Naphthalene, "	4.0 — 6.00	6.0 — 9.0
Anthracene, "	0.5 — 0.	0.5 — 1.0
Pyridine bases,	0.25	0.25
Creosote oils,	20.0	20.0
Pitch,	50.0 —60.0	50.0

Shale is distilled in vertical retorts, arranged for continuous feeding and discharge. The upper half of the retort is iron and the lower part, where the heat is intense, is fire-brick. The vapors evolved pass through a series of 4 inches vertical con-

densers, where the ammoniacal liquor and crude oil are separated. The gases are then scrubbed with water, to recover more ammonia, and then scrubbed with oil of about 0.856 sp. gr., which absorbs the "illuminants," then the gas is burned for fuel. The retorts hold about 5 tons of shale, and the yield per ton is about:—

15,000 cu. ft. gas, 40 to 72 lbs. sulphate ammonia, 20 to 30 gallons crude oil.

Crude shale-oil is of a dark green color, is semi-solid at ordinary temperature, and contains 70 to 80 per cent. of paraffine and olefine hydrocarbons, and some pyridine bases and phenols. It is refined by distillation, with precautions against cracking. Light burning oils, mineral lubricator oils, and solid paraffine wax are obtained.

Bones are distilled in iron or fire-clay retorts, and yield gases, ammoniacal liquor, equal to 7 per cent. of the weight of the bone as ammonium sulphate, and Dippel's oil or tar, usually amounting to about 2 per cent. of the raw bone. The residue of bone-char is 65 per cent. of the original weight of the bone.

The bones are cleaned from fat and meat, dried, crushed to small size, and fed into the retorts directly. The gases are scrubbed to recover the ammonia, and then are burned in the furnace. Bone-oil contains pyridine bases, which are separated by fractionation; some decomposition occurs, and the residue of the distillation is a pitch, used for Brunswick black.

Waste horn, leather, hair and other **Refuse,** are sometimes distilled to recover ammonia, and the coke is used for the manufacture of ferrocyanides. About one-fifth of the nitrogen of the original material, remains in the coke, which consequently is fit for cyanide making.

Peat is sometimes destructively distilled, chiefly to obtain the coke, which is free from sulphur. In Sweden, peat is coked in Otto-Hoffmann ovens at 400° to 600°C. Since it contains considerable oxygen, the gases are high in carbon dioxide and carbon monoxide; this lowers the candle power and makes the gas expensive to purify. The aqueous distillate from peat is

very dilute and is low in acetic acid. It contains some ammonium sulphate, methyl alcohol and calcium acetate. The yield of tar is also very low, and it contains much free carbon, and a little anthracene. Its odor is unpleasant and acrid. The yield is about:—

Gas,	21 %	Tar,	4 %
Tar water,	40 %	Coke,	35 %

Resins, especially common rosin, are distilled destructively, and various liquid products, e. g., rosin spirits, rosin oils and pitch, are obtained. The light distillate (rosin spirits), finds use as solvent and thinning material in varnish and paints. The rosin oils are heavy liquids, much used as lubricators and for mixing with mineral and vegetable oils. Certain fossil gums, copal, kauri, and others, are heated in copper kettles until about 20 to 30 per cent. of their weight has been distilled off, as very acid vapors, which are usually allowed to go to waste. The remaining "gum" in the kettle, is then mixed with drying oils and turpentine, to form varnish. As a rule, no recovery of the light oils is attempted, though they have undoubted value as solvents.

Garbage and the various waste organic matters collected in cities, are frequently destroyed by burning in special furnaces or destructors. Attempts have been made to subject them to dry distillation, more especially to procure ammonia compounds, and have left, a coke, suitable for fuel, or for the manufacture of ferrocyanides. But these methods have not proved financially successful, as a rule, and the destructors are often used only to get rid of a nuisance as cheaply as possible.

The distillation of resinous fat pine (light-wood) was started in North Carolina, in 1872, for the purpose of recovering the turpentine and rosin, in addition to pyroligneous acid and tar. This attempt failed, but in 1878 the industry was reestablished, but made little progress until a few years ago, when more systematic and improved methods of distillation were introduced, whereby the yield and quality of the turpentine produced, has been much improved.

The retorts hold about five cords and the distillation is aided by the introduction of steam (sometimes superheated) into the retort. The crude products of the distillation are:—

Amber oil,
Pyroligneous acid,
Gas,
Tar.

The oil on fractionation yields turpentine and creosote oil. By re-distilling the crude turpentine with steam the commercial **wood turpentine** is obtained. This still retains an empyreumatic odor.

The wood remaining in the still after the steam distillation, is then dry distilled, to obtain pyroligneous acid, tar, and charcoal. The residue from the turpentine distillation is rosin, which is itself dry distilled to obtain rosin oils and pitch.

Yield per cord (6000 lbs.) from Distillation of Hard Pine.

Turpentine,	3. %		
Rosin,	5.2	Gas,	20. %
Rosin spirit,	0.3	Charcoal,	17.5
" oil,	1.5	Tar,	20.28
Heavy oils,	1.8	Creosote oil,	5.1
Pitch,	0.2	Wood pitch,	8.6

At the close of the afternoon session a vote of thanks was extended to the speakers of the day. The meeting adjourned at 4.30 P. M.

CHARLES W. GOODRICH, Secretary.

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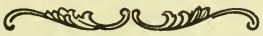

Report of the Thirty-sixth Regular Meeting.

New England Association of Chemistry Teachers.

The thirty-sixth regular meeting of the Association was held Saturday, December 4, 1909 in Boylston Hall, Harvard University, Cambridge, Mass.

PROGRAM.

MORNING SESSION.

10.00 A. M. Meeting of the Executive Committee.

10.15 A. M. Business Meeting.

Election of New Members.

Annual Report of the Treasurer.

Annual Report of the Secretary.

Report of the Committee on Current Events and Publications.

Report of the Committee on New Apparatus.

Report of the Committee on New Books.

New Business (Proposed Amendment of Article III, Section 1 of the Constitution).

To read: — Annual dues of Active Members shall be $3.00 *and of Associate Members,* $1.00.

11.45 A. M. "Some Experiences of an American Teacher in the German Higher Schools."

Lyman G. Smith, High School of Commerce, Boston.

12.30 P. M. Address. "The Value of Investigation to the Teacher of Chemistry."

Prof. T. W. Richards, Harvard University.

Prof. Richards is one of the most prominent leaders of chemical research in the world and he is probably the world's greatest authority on atomic weights.

1.15 P. M. Luncheon at Dunster Cafe.

AFTERNOON SESSION.

2.30 P. M. Election of Officers.

3.15 P. M. Industrial Chemistry.

"Illuminating Gas Manufacture"

Nettie M. Willey, High School, Peabody, Mass.

"Sulphuric Acid Manufacture"

Laura P. Patten, High School, Medford, Mass.

"Iron and Steel Manufacture"

Owen D. Evans, Boston, Mass.

"Soda Manufacture"

Harold Bisbee, High School, Dorchester, Mass.

Ten minute papers, considering especially (a) How the subject is presented to the class, and (b) How much the pupil is expected to know and to remember.

An important and suggestive discussion followed in which the following took part: Lucy E. Allen, Winthrop, Mass.; F. R. Hathaway, Salem, Mass.

The meeting was called to order by the President, Augustus Klock, at 10.15 o'clock.

The first business attended to was the election of new members.

The following candidates, recommended by the Executive Committee, were elected members of the Association.

FOR ACTIVE MEMBERSHIP.

Edward Solon Bryant, High School, Everett, Mass.
William N. Ross, English High School, Providence, R. I.
Harriet B. Lord, High School, Revere, Mass.

FOR ASSOCIATE MEMBERSHIP.

Ira M. Bearce, High School, Fitchburg, Mass.
Henry Ernest Williams, Acadia University, Wolfville, N. S.

ANNUAL REPORT OF THE TREASURER.

November 14, 1908, Due Allen Print on account of report,	$35 15	
November 14, 1908, Cash on hand,	11 41	
" " " Deficit,	$23 74	
Received dues from members for 1909,	$217 00	
November 14, 1908, Cash on hand,	11 41	
Total Received,		$228 41
Paid on account for 1908 report,	$35 15	
" American Federation dues for 1908,	8 45	
" " " " " " 1909,	8 50	
" American Trust Co. for collecting checks,	20	
" for reports, programs, and stationery for 1909,	$164 61	
Toral paid out,		$216 91
December 4, 1909, Due for expenses of 1909,	$29 90	
" " " Cash on hand,	11 50	
" " " Deficit,	$18 40	
1910 dues received in advance,	$8 00	

LILLIE C. SMITH, *Treasurer.*

ANNUAL REPORT OF THE SECRETARY.

The thirty-third meeting of the Association was held at the Worcester Polytechnic Instititute on November 14, 1908. At this meeting Professor Jennings delivered an address on "Alchemy, Past and Present." This address was illustrated by lantern slides and it was both interesting and instructive. Dr. McFarland's "Elementary Principles of Chemistry" was reviewed at the morning session. The advisability of teaching in a first year course the theory of electrolytic dissociation, the mass law, osmotic pressure and the determination of molecular weights was discussed and many differences of opinion were brought out.

The morning session of the thirty-fourth meeting was held at Simmons College, February 13, 1909. Wilhelm Segerblom's "Qualitative Analysis" was reviewed at this meeting. Mr. Peterson spoke in appreciation of the work of Mr. Edward F. Holden. Professor Norris spoke on recent advances in chemical conceptions of valence. Prof. Henry P. Talbot's address brought clearly to mind the difficulties involved in the teaching of chemistry. The Association is deeply indebted to Professor Talbot for the very careful review of the relations existing between the colleges and the secondary schools. At the afternoon session Prof. Frank H. Thorp gave an illustrated lecture on Destructive Distillation. This lecture was one of the lectures of the Saturday course on Industrial Chemistry.

The thirty-fifth meeting was held at Boston University on May 8, 1909. Prof. Louis Derr gave a very interesting account of the development of the Photographic Image. Mr. Arthur A. Blanchard spoke on the "Passive State of Metals." Prof. Lyman C. Newell in his "Chemical Pilgrimage" gave material of the greatest value. Rare books and portraits were shown by Professor Newell and the opportunity of seeing these was an unusual one.

Through the kindness of Prof. A. Lawrence Lowell, a

course on Industrial Chemistry was given free of charge to the members of the Association. Prof. Frank H. Thorp conducted this course and through his conscientious work those taking the course were supplied with a wealth of material on the subject of Industrial Chemistry.

This year a course has been arranged on the Chemistry of Food. Prof. A. G. Woodman is to conduct the course and two of the fifteen lectures were given during November. At the present time sixty-nine people are taking the course under Professor Woodman.

The membership of the Association is at present: honorary, 17; active, 73: associate, 100, making a total of 190 members. This same number was reported last year at the annual meeting. Fourteen members have resigned during the year and one of the active members has asked to be changed to an associate member.

Every attempt has been made to publish reports of the meetings in full for the benefit of those who are unable to be present. It is earnestly desired that all teachers of chemistry in the vicinity of Boston become active members and take an active part in pushing forward the work of the Association.

Respectfully submitted,

CHAS. W. GOODRICH, *Secretary*.

REPORT OF THE COMMITTEE ON CURRENT EVENTS.

Prof. LYMAN C. NEWELL, Chairman.

GRAPHITE. An advance chapter on mineral resources for 1908 on Graphite in the United States contains an interesting and accurate account of the physical and chemical properties, origin, uses and production of natural graphite, together with a bibliography. Copies may be obtained free from the Director, U. S. Geological Survey, Washington, D. C.

The Graphite Tradesman, August 15, 1906 (published by

the Joseph Dixon Crucible Company, Jersey City, N. J.) contains an article on the history and method of lead pencil manufacture. The Joseph Dixon Crucible Company, John Hancock Building, Boston, Mass., will send free on request a sample card showing the progressive stages in lead pencil manufacture.

The production of artificial graphite increased from 6,590,000 pounds in 1907 to 7,385,511 pounds in 1908, while the price dropped from $7\frac{3}{10}$ cents to $6\frac{4}{5}$ cents a pound.

TUNGSTEN, TANTALUM, VANADIUM AND TITANIUM. An advance chapter on mineral resources for 1908 contains valuable information on these metals. This pamphlet may be obtained free from the Director, U. S. Geological Survey, Washington, D. C.

The General Electric Company, Schenectady, N. Y., will send on request their pamphlet 34 on tungsten, which contains information about tungsten lamps.

Nature, May 6, 1909, contains an article on Tantalum and its industrial uses.

PLATINUM. A pamphlet on Platinum, similar to the above mentioned pamphlets may be similarly obtained.

The Baker Company, dealers in platinum, will send on request a useful pamphlet on Platinum. Address is Newark, N. J.

IRON ORES, PIG IRON AND STEEL. A similar pamphlet on this general topic has in a pocket two unmounted maps, one showing the distribution of iron ores, the other the location of blast furnaces.

The Journal of Engineering and Industrial Chemistry, March, 1909, page 209, contains an illustrated article on the vast steel plant at Gary, Ill.

SEWAGE PURIFICATION. See Water Supply Paper 229, U. S. Geological Survey.

RADIOACTIVITY OF THE WATERS OF YELLOWSTONE NATURAL PARK. See Bulletin 395 of the United States Geological Survey.

SILICON FURNACE. A short illustrated article on the silicon furnace is in Electrochemical and Metallurgical Industry, November, 1909, page 495.

PETROLEUM AND ITS PRODUCTS. A set of bottled samples of crude and refined petroleum can be obtained of the Standard Oil Company, 26 Broadway, N. Y., upon presentation of satisfactory evidence as a suitable recipient.

CARNEGIE INSTITUTION. The Carnegie Institution, Washington, D. C., will send on request an annotated list of their publications on chemistry and physics.

GAY LUSSAC'S LAW. Nature, October 28, 1909, contains a helpful summary of the history of this law which was announced just a century ago this month (December).

REPORT OF THE COMMITTEE ON NEW APPARATUS.

A. M. BUTLER, Chairman.

Fitzgerald's constant level apparatus for filtering was shown and described. Price $2.50. J. T. Baker Chemistry Company.

Mr. O. D. Evans spoke of the use of Apparatus A for determining the flash point of kerosene. The inner cup when filled to the brim with oil makes a good open cup apparatus. A slight variation in height of the oil makes a great difference in the result obtained.

REPORT OF THE COMMITTEE ON NEW BOOKS.

GEORGE A. COWEN, Chairman.

Elementary Modern Chemistry. Ostwald & Morse. Ginn & Co. Reviewed by Lyman G. Smith.

Those who have enjoyed the fresh scientific style of Professor Ostwald, or who have had the privilege of listening to his original methods of teaching chemistry as outlined a few years ago in his lectures at Harvard, will welcome this elementary exposition of the subject. Departing boldly from established traditions, chemistry is developed logically on the physical basis. Mixtures and homogeneous substances, phases, the three states of matter, and solutions are simply and clearly defined in the first fourteen pages of the book. The chemistry of the common elements is included in the main body of the text, and the modern applications of physical chemistry are employed in the explanations. The excellent treatment of electrical work, and the discussion of alloys deserve special mention.

Teachers who are looking for a practical systematic course of laboratory work will probably be disappointed in the book. With this exception, it will be found useful. With a good teacher, and some previous knowledge of physics, the average inquiring high school boy will find much help in this little volume, which is not only valuable on account of the new matter introduced, but especially useful on account of the regulation topics which it has left out. There are several excellent portraits, and the explanatory diagrams are exceptionally well drawn. Teachers who do not misuse text books will appreciate this contribution to the teaching of elementary modern chemistry.

Elementary Chemistry. By Frederic B. Emery, A. M., McKinley High School, St. Louis, Mo. Chemical Publishing Co., Easton, Pa. Price $1.50. Reviewed by Wilhelm Segerblom.

The preface opens with a statement of the author's beliefs regarding the teaching of elementary chemistry, viz. (1) that the elements and their more important compounds should be treated fully; (2) theory should be stated as early as the student can understand it; (3) human interest should be

maintained by the historical treatment; (4) physical chemistry, industrial processes, and brief organic chemistry should be included; (5) subject should be made practical through everyday life illustrations; (6) mathematical problems should be included as far as time permits; (7) experimental work should follow the order of the text but cover different details, and (8) sufficient detail should be given to enable the student to work intelligently. The rest of the preface reads well chemically and contains much sound doctrine.

The book itself is divided into four parts.— I, General Descriptive; II, Mathematical; III, Experimental, and IV, Tables. Part I contains seventeen pages of introductory matter. Next follows 216 pages on the non-metallic elements and their compounds in the usual order, but in the midst of these are inserted five chapters on theory. Next comes 114 pages on the metallic elements and their compounds, in amount rather small when compared with the space devoted to the non-metallic substances. Alloys are treated unusually fully. Part I concludes with fifty-five pages on organic chemistry, the treatment of which, to quote from the preface "does not follow the time honored order." Part II on mathematical chemistry covers thirty pages, "grouped in a single section so that teachers who have an aversion for this part of the work may omit it entirely without breaking the continuity of the text," a view not quite consistent with the doctrinal opinion set forth in the opening beliefs. Closer examination also reveals that Part II is simply a long list of problems with the methods of working the problems over 250 pages away from Part II. Part III, 184 pages, contains directions for laboratory work, opening with five pages of most sensible general advice that certainly ought to make the pupils careful thinking workers. This is followed by pictures of pieces of apparatus frequently used in the laboratory, a splendid idea, but spoiled in this case by extending over sixteen pages; a judicious selection here would have been wiser. Hasty examination of the direction themselves

indicates that they are carefully and thoughtfully prepared. Part IV contains many tables that are interesting and helpful.

The author epitomizes the essentials of a good teacher and a good text when he says: "Ideally, all teachers of chemistry should be thoroughly prepared and should be in love with the subject. . . . One aim of the author has been to make the descriptions so clear that the average teacher would not have any difficulty in explaining to the class the meanings." He has held himself to these aims and has included only what has been tried out in his own classes.

The text contains 191 cuts, a few of which are half tones. Equations are used early and freely, the equality sign being replaced by the arrow. Structural formulas appear in the section on organic chemistry. Concise summaries follow the chapters.

At first glance the book presents an attractive appearance typographically, but it is a pity that more care was not taken in the selection and composition of the type. The title page does not make a pleasing initial impression. This disadvantage is further enhanced by the fact that the preface is set in a small font of type. The paper is so thin that print shows through in many places. Perhaps it had to be so to get the 666 pages into the book, but the author should not be held responsible for these faults.

To the teacher who believes in the method of presenting chemistry that has been in vogue for some time this book should appeal strongly, for it brings into the field fresh enthusiasm coupled with laboratory saneness. One feels instructively that another good and *parallel* effort has been made; but one cannot help wondering if we are on the best track and if there is not some method yet undiscovered, of presenting the subject in a more *logical* manner and more as a *unified whole*.

First Year Chemistry. Wilhelm Segerblom. Exeter Book Publishing Co. Reviewed by George A. Cowen.

This is not a text book, neither is it an ordinary laboratory manual. It takes the place of both. It requires the presence of the pupil in the laboratory by far the larger part of the time but it will at the end of the course have furnished the pupil, with a knowledge of elementary chemistry. In the hand of a skilful man, it will give the best of results, but will not fit all kinds and conditions of classes.

There are 169 exercises. In the first ninety, the author follows a strictly inductive method. The order is somewhat changed from the ordinary hydrogen, oxygen, water, etc., to copper, zinc, magnesium, phosphorus, iron, mercury, oxygen, etc.

The next twenty pages are devoted to historical and biographical chemistry. This is followed by the language of chemistry and theory. The time and place for these seem well chosen.

The remainder of the book considers the common and important metals with their compounds.

There are many helpful tables and outlines. A very complete outline is given at the end of the book.

In the appendix, one finds a hundred or more selected problems, each kind in a group by itself.

It is a book that every teacher ought to own, and one that some can use in his classes with profit.

Under the head of New Business the proposed amendment to the constitution was discussed but was not passed.

Professor Norris moved that the N. E. A. C. T. ask the American Federation of Teachers of Mathematics and Science to consider the question of submitting to the College Entrance Examination Board a request for a consideration of the advisability of a change in the definition of the requirement in chemistry. The motion was carried.

It was voted to lay upon the table, the recommendation of the executive committee relating to the withdrawal of the Association from the American Federation of Teachers of the Mathematical and of the Natural Sciences.

The Association then proceeded to elect by ballot the officers for the ensuing year.

President, AUGUSTUS KLOCK, Beverly High School.
Vice-President, FREDERICK C. ADAMS,
Mechanic Arts High School, Boston.
Secretary, CHARLES W. GOODRICH, Waltham High School.
Treasurer, ALFRED M. BUTLER, East Boston High School.
Executive Committee,
HAROLD BISBEE, Dorchester High School.
EMERSON RICE, Hyde Park High School.
WILHELM SEGERBLOM, Phillips Academy, Exeter, N. H.

It was voted that the Association be incorporated.

Professor Newell moved that we send an account of our work to the American Federation. This was carried.

Mr. F. C. Adams' motion that the executive committee be appointed to offer hospitality to visitors during Convocation Week was carried.

Mr. Lyman G. Smith of the Boston High School of Commerce, one of the exchange teachers sent to the higher schools of Prussia, by the Carnegie Foundation for the Advancement of Teaching, said in part:—

It is always a difficult matter to describe accurately conditions in a foreign country, but after considerable favorable opportunity for observation, teaching, visiting schools, talking with educators, and reading, I venture to accept the invitation of your president, and to present to you some conclusions and comparisons which are the result of my acquaintance with the higher schools of Prussia.

The educational system of Germany is frequently spoken of as the best in the world. There are many good grounds for this statement. The number of illiterate persons is exceedingly small, the proportion of youth attending school is very large, various forms of special education reach all classes and capacities, the general average of scholarship is high, educational funds are liberally and wisely expended, teachers

are honored, and are retired on adequate pensions, and there is a lively and healthy public interest in educational problems. The system reaches the humblest and the youngest, and appears to neglect none, but may be an especially profitable example for us, if we note the high efficiency exhibited by the administration, the instruction, and the product of the secondary or higher schools.

The German system is essentially different from that in our own country, for in Prussia boys enter, at six or seven years of age, the school in which they will study under the same or nearly the same teachers continuously for some twelve years. The *Vorschule*, or primary department takes three years, and the other classes occupy normally nine more years. With the end constantly in view, and a clearly defined program and purpose, and with no abrupt transition point like that between our high and grammar schools, the work reaches a remarkable degree of efficiency. The three highest classes are known as *Prima*, *Sekunda*, and *Tertia*, each of which is divided into an *Ober-* and an *Unter-* section, one year being assigned to the work of each of these six sections; *Quarta*, *Quinta*, and *Sexta*, one year each, and the three years of the *Vorschule*, complete the time assigned to these higher schools. There are three distinct types, the *Gymnasium*, with a strictly classical course, the *Realgymnasium* with Latin and no Greek, and the *Oberrealschule* with no instruction in ancient languages; but these have all, by royal decree, been declared equal, and those who complete the requirements of the school course may enter the university without taking admission examinations. In fact, this test is fully covered by the very searching written and oral *Abiturienten Examen*, held at the close of the school course, and conducted by the *Schulrat*, the official representative of the government. The education for girls is planned on similar lines, but is considerably modified, and much less rigorous in content and in application. The statements made here refer more particularly to the education of boys.

The most conspicuous feature of the higher school course of study is the early age at which boys begin what we commonly term "high school studies." The corollary to this is the long period of years which each boy is able to devote to the pursuit of ancient and modern languages, mathematics, and science. Latin, for example, may be begun at nine years of age, and pursued for five years eight hours per week, and for four more years seven hours per week, or an average of seven and a half hours per week for a total period of nine years. With five hours per week of mathematics, covering a period of seven years, nine years of French, seven years of English, geography, biology, or other natural science all through the course, we are not surprised that the results show attainment considerably beyond that of our own pupils. There are six school days in the German week, and thirty-five or even forty school periods per week may be assigned to pupils, most of these recitations requiring preparation at home. There are no "study hours" in school.

A moderate tuition fee is generally charged. This increases the importance and the sincerity of the co-operation of parents, and it seldom fails to promote the progress of pupils. At the same time, state and local support by tax levy is very large in proportion; and the government exercises strong control and influence over the educational policy. The local authority in higher school administration is mainly nominal, and there is little or no political interference with Direktor or teachers. In general, higher school direction comes from the Ministry of Education at Berlin, with subordinate provincial management, and the academic and personal qualifications of the governing officials appear to be of a high order. Appointments seem to be remarkably free from corrupt political intrigue.

The science teaching, however, while thorough, is not according to the methods most approved in our best schools. The text-book plays too important a part, and the laboratory method has not, so far at least, been very generally adopted.

This is due to several causes. The old classical faction has organized itself into a party which has opposed modernism in education. A large proportion of the science teachers and most of the Direktors have been educated in the classical schools. Many of the science teachers have themselves not done practical laboratory work until they entered the university; and elementary and introductory laboratory courses in the university are seldom good models for secondary schools. University professors are not certain as to the advantage of pupils beginning laboratory work in school. Some of the science teachers themselves seem unfamiliar with both the content and the spirit of elementary laboratory instruction, though there are conspicuous examples of teachers who have contributed excellent work in this direction. All these difficulties are not foreign to American teachers, and laboratory study is still contending for its appropriate share of hours in the program. In fact, laboratory exercises in Prussian schools are usually elective, or voluntary, or both, and poorly attended. On the other hand, the text-book study of science is thoroughly carried out, and the lecture-tabledemonstration by the teacher is of a very high grade of excellence. The educational administration and the leaders in science teaching are doing all they can to promote practical exercises, the emperor has formally decreed this among other educational reforms, and many of the newer schools have laboratories of remarkable extent and equipment and science teachers of great enthusiasm and efficiency.

Pupils eighteen or nineteen years old who have passed both a written and an oral examination in analytic geometry and in differential calculus, or who, in addition to the classical authors usually read in American high schools, have done considerable portions of Horace, Livy, Plato, and Demosthenes, who have learned to speak French fluently, who discuss Hamlet and Macbeth in ready English, who read Dante's Inferno, or the Hebrew prophets, in the original, for a pastime, are certainly equipped with an educational training far ahead of that

of their American nineteen year old cousins who are high school graduates. In feats of skill in the gymnasium or *Turnhalle*, or in games (except baseball and football), the average American boy would have to take an inferior rank. The difficulty of the musical works sung and the accuracy of their performance far exceeds that in our schools.

We can but inquire how far we are progressing in one of the important and proper aims of public education, that is, training up a considerable body of youth who will perpetuate our present fund of learning and will, moreover, enlarge it by promoting and pursuing productive scholarship in America.

A number of lantern slides, illustrating German life and school customs were shown with appropriate comment.

THE VALUE OF INVESTIGATION TO THE TEACHER OF CHEMISTRY.

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Prof. T. W. Richards, Harvard University.

This subject, which your kind president has helped me choose for the occasion, is one which has only recently been considered as worthy of serious attention in America. Thirty-five or forty years ago chemical research in the American educational institution was almost unknown. The ideal college was supposed to be typified by President Mark Hopkins sitting on one end of a log and a single student on the other. This ideal was indeed admirable in its way; but it was limited. The teacher thought he had fully served the purpose of his being if he imparted to others more ignorant than himself the reflected knowledge which he in turn had acquired from those before him. Vaguely, perhaps, he realized that someone must in the first place have discovered these things which he taught, that master-minds must have had in time past glimpses into new relations and that

these glimpses had been the means of inculcating new ideas into human learning, but this vague feeling did not enter into the practical conduct of his profession. As long, however, as the main topic of instruction continued to be essentially the classics and mathematics, the need for research was not so immediately apparent. For the classical languages would naturally be supposed to remain essentially that which they have been known to be for many centuries, and the most obvious relations of mathematics are likewise unchangeable in spite of the modern enthusiasm for the extra-Euclidean point of view. I do not for a moment mean to imply that research in the classics or research in mathematics are without worthy object or great value. The careful study of manuscripts and antiquities will undoubtedly reveal details and relationships which even now have escaped recognition, and the extension of the new non-Euclidean mathematics as well as of the comparatively recent although less startling development of vector algebra and quarternions will certainly lead to more profound mathematical conceptions than any which we have at present. The mathematician can even now solve only a tithe of the problems presented to him by nature; nevertheless, the practical elements of mathematics with which the teacher or the average human being has to do, will, I repeat, not greatly change. Not even the non-Euclidean enthusiast can make two and two equal five.

And so it has come to pass that in the field of natural sciences, especially, research has been prominent; for here is a great field concerning the immediate relation of man to his environment, to his own structure, and to the mechanism of his very thought and being, which lay almost unexplored two centuries ago, and which has received careful attention only in the last century. It is with research in natural sciences, particularly in physical science, that the present address is concerned. By physical science of course I mean to include both the sciences of chemistry and physics, sciences so closely allied as to be in many ways almost inseparable.

You know that chemistry is a new science and that a century and a half ago it might well be said to have been non-existent. Indeed, Kant made this definite statement. It is true that the alchemists and the so-called iatro-chemists carried out their mystic experiments; that a few gentlemen with philosophical leanings, like, for example, Sir Henry Wotton, the English ambassador to Venice in the reign of James the First, engaged in chemical experiments as a pastime; that Robert Boyle, that highly gifted son of an old Irish nobleman, had to some extent brought order into the chaos of these earlier views; but it was not until Black and Lavoisier had taken the balance seriously that real progress was made. Since that day chemistry has taken amazing strides, and every step has come through patient, clear-sighted research. We may well say that not only our fascinating science, but all the multifarious manufactures and medical triumphs of modern times depend in large measure upon this research. These priceless gains to humanity are the fruit of the seeds planted by a few score men of genius in the course of a century and a half. Often the seed needed much watering and the plant needed careful tending and intelligent pruning and grafting before it could be got to yield this fruit, but the pruning and grafting also were effected by patient study. From this one may conclude that whatever may be the good of research to the teacher, its good to humanity is beyond all reckoning.

You may be inclined to ascribe this high estimate of research to the enthusiasm of a single specialist, one who has perhaps settled into a rut and can proceed only in a single narrow path. In order to show that this is not merely the opinion of a single individual, let me quote Dr. Charles Sprague Minot, a man of wide scientific and medical experience, and a student in a direction quite different from that of the chemical investigator. He speaks in his new, highly interesting book on Age, Growth and Death, as follows:

"Scientific research offers to its devotees some of the

purest delights which life can bring. The investigator is a creator. Where there was nothing he brings forth something. Out of the void and dark he creates knowledge, and the knowledge which he gathers is not a precious thing for himself alone, but rather a treasure which by being shared grows; if it is given away it loses nothing of its value to the first discoverer but acquires a different value and a greater usefulness in that it adds to the total resources of the world. The time will come, I hope, when it will be generally understood that the investigators and thinkers of the world are those upon whom the world chiefly depends. I should like, indeed, to live to a time when it will be universally recognized that the military man and the government maker are types which have survived from a previous condition of civilization, not ours; and when they will no longer be looked upon as the heroes of mankind. In that future time those persons who have really created our civilization will receive the acknowledgement which is their due. Let these thoughts dwell long in your meditation, because it is a serious problem in all our civilization today how to secure due appreciation of the value of thought and how to encourage it. I believe every word spoken in support of that great recognition which is due to the power of thought is a good word and will help forward toward good results." Thus speaks Professor Minot.*

Perhaps some of you will think that this also is the saying of one, who, having given much time to research, is greatly prejudiced in its favor. For this reason I propose to quote two others as widely different as possible both from the investigator and from one another. The first of these two is Mr. Lowes Dickinson, the radical thinker of Cambridge, England, a man steeped in the traditions of ancient learning and filled with the spirit of an almost Utopian ideal of democratic development. As you know, Mr. Dickinson has recently lectured at Harvard upon immortality and upon the ideals of democracy, and his tolerant and suggestive discus-

* Age, Growth, and Death," page 231 (G. Putnam's Sons, 1908.)

sion of these exalted subjects has heightened the interest of thoughtful people in his views. In his recent book, entitled "Justice and Liberty," he arraigns the capitalistic tendency of the age in no unsparing terms, and in speaking of modern "promoters," he puts into the mouth of one of his characters the following words:

"These men, [financiers] clearly, whatever else they are, are not the originators of ideas. It is not they who are the discoverers and inventors, but quite a different kind of man, the sort of person they despise as academic and unpractical, actuated by a passion which also they would despise, if they could comprehend it, the love of truth. Dalton and Faraday, Clerk Maxwell and Kelvin, these men were not financiers, nor capitalists, nor were they moved by cupidity; yet it is upon them and their like, more than upon anything else, that the progress of production depends." *

But Lowes Dickinson is a dreamer, you may say, and dreamers are always unpractical. How should he know whether or not the progress of production and the upward tendency of civilization rests primarily upon research?

Let us quote therefore someone from an entirely different walk of life, an extraordinarily able person, who in a single lifetime has accummulated an imperial fortune, namely, Andrew Carnegie. Andrew Carnegie stands for a form of activity and attainment as far as possible removed from the ideals toward which Dickinson is striving. In his deed of gift of $10,000,000 to the new Carnegie Institution of Washington, Carnegie specifies the various purposes to which this institution is to be devoted; and his specifications begin as follows:

"Among its aims are these: 1. To promote original research, paying great attention thereto as one of the most important of all departments." †

So Andrew Carnegie, practical iron-master, shrewd finan-

* G. Lowes Dickinson "Justice and Liberty," page 122 (New York, 1908.)

† Carnegie Institution of Washington, Year Book, I, xiii. (1902.)

cier, great benefactor, agrees with the medical thinker, and the socialistic idealist.

Enough opinions of men of unusual intelligence, as different as may be in their characteristics, have been quoted It would be very presumptuous in your lecturer to disagree with such opinions. Indeed, he has no desire to disagree with them. He tells you without hesitation that he believes their conclusion is the only sound one, and reiterates the statement that the growth of modern civilization must rest in large degree upon research, in the future as in the past.

But all this has not yet attacked the immediate subject of the lecture, namely, the use of research to the teacher. The limitation could not, however, be applied, until the value of research in general had been touched upon. There can be no question that the value of any subject or attitude of mind to the teacher depends largely upon the value of that subject or attitude of mind to the world at large. For it is the noble business of a teacher to train the youth of the land in those paths of mental progress which will lead him to the better and richer development of his subsequent life, either because of their immediate utility, or because of the broadening or deepening effect which these subjects may exert upon the growing mind. Let me repeat: because research is of value to the world, it must not be left out of the teacher's reckoning.

Has it not often been left out of the teacher's reckoning?

In America, we know so little about it that many of us even pronounce the word incorrectly. We put the accent upon the first syllable instead of upon the last, emphasizing the *re* rather than the *search*. I prefer to accent the other end of the word, not only because Webster and Worcester combine in this recommendation, but also because I like to think of investigation as a *search* rather than as a repetition of other work, the idea suggested by the first syllable. Our lack of understanding of research is made evident not only by this trivial matter of pronunciation, which really does not matter much one way or the other; it may be inferred from

other more significant facts. Many of our text-books have in the past treated science, in the imperfect state in which it happened to be at the time of writing, as a fully developed and complete entity — a Venus risen full grown from the sea, a message straight from the gods. Such books give the student no idea of the slow and gradual process by which human minds and human hands have gradually built the science, and convey no conception of the imperfection which still hides its more profound relations. I remember, for example, in my youth having studied a text-book upon chemistry which declared in positive unequivocal terms that the rotting of apples and peaches is due to the oxygen of the air, and is directly comparable to rusting. May we not even now, perhaps, be teaching something which will fifty years hence appear as absurd as this statement does today? Some of you may argue that an elementary course in chemistry is not the place for the study of the psychology of science or of the history of scientific development, and in certain measure the objection would be well-timed; but on the other hand, it seems to me that we should never lose sight in our teaching of the fact that all the phenomena, the laws and the hypotheses with which we have to deal, have after all been discovered and wrought into a partially consistent fabric by the minds of men, and that their truth or validity are all affected by the necessary limitations of human mentality. As Ostwald said to me once, "One's chemical banquet must inevitably always be seasoned with a pinch of psychology. That is the savor which makes the food wholesome." He meant that until we know something of the mental processes of the discoverer, we could not properly interpret the discovery.

Now, I would not for a moment recommend that you give hours or days to the formal study of the psychology of the scientific mind, or to any stated teaching of this subject. It seems to me, however, that it would be well to emphasize from time to time the undeniable fact that this or that great mind had first grasped this or that relationship. By flavor-

ing the matter with a little history, one must quite imperceptibly introduce a flavor of psychology also, enough to awaken unconsciously the student's perception of the part played by man in the evolution of his science. I have no doubt, indeed, that many of you have done this for years.

You all know that the only way really to understand any subject of human endeavor is to have taken part or at least tried to take part in it. It has been said that the art critic develops from the unsuccessful artist, and that the literary critic is one who cannot himself create. But to every mind this pleasantry is highly unjust to the really good critic. He will be a poor critic who has not at least partially succeeded in doing something original. It seems to me almost unavoidable that such a man's criticism should be pointless, that he really could not understand the aims or methods of the work which he attempted to probe. The good critic must himself have the same type of imagination as that needed by the author. As a corollary of this, it follows that the teacher who would give his best to the student must have acquired some knowledge of research by actual experience. But this is a great deal to ask; before one can extend the bounds of knowledge, he must have already come pretty near to the boundary, in some one direction, far enough, at least, to obtain a distant prospect of undiscovered country. In the highly developed science of chemistry today it is a long and sometimes weary march which takes one to the boundary, a march full of interest to be sure, but requiring years of patience and thought. Many of us have not time to reach the boundary, much less to walk beyond it, and many there are who were not made by nature for the prosecution of research. There is no use of trying to conceal the fact that no really original thing can be done merely by saying, "Go to, I will make an investigation." Let us quote for a moment from Jevons, the great logician, in order to see what qualities are necessary in order to do really original work.

" . . . It is a work of undiminished interest to reflect upon

those qualities of mind which lead to great advances in natural knowledge. Nothing, indeed, is less amenable than genius to scientific analysis and explanation. Even precise definition is out of the question. Buffon said that 'genius is patience,' and certainly patience is one of its most constant and requisite components. But no one can suppose that patient labor alone will invariably lead to those conspicuous results which we attribute to genius. In every branch of science, literature, art or industry, there are thousands of men and women who work with unceasing patience, and thereby ensure at least a moderate success; but it would be absurd to assent for a moment to crude notions of human equality, and to allow that equal amounts of intellectual labor yield equal results. A Newton may modestly and sincerely attribute his discoveries to industry and patient thought, and there is much reason to believe that genius is essentially unconscious and unable to account for its own peculiar powers. If genius, indeed, be that by which intellect diverges from what is common, it must necessarily be a phenomenon beyond the domain of the ordinary laws of nature." . . .

"The natural philosopher must therefore have, in the first place, a mind of impressionable character, which is readily affected by the slightest exceptional phenomenon. His associating and identifying powers must be great, that is, a single strange fact must suggest to his mind whatever of like nature has previously come within his experience. His imagination must be active, and bring before his mind multitudes of relations in which the unexplained facts may possibly stand with regard to each other, or to more common facts. Sure and vigorous powers of deductive reasoning must then come into play, and enable him to infer what will happen under each supposed condition. Lastly, and above all, there must be the love of certainty leading him diligently and with perfect candour, to compare his speculations with the test of fact and experiment." *

* W. Stanley Jevons' "Principles of Science," pages 219–221, (New York, 1874).

Now these are rare qualities, and it would be unreasonable to expect to find them in every teacher, however excellent he might be. They are not exactly the same qualities as those needed by the teacher. Among these latter I would place almost at the head of the list that warm human sympathy which enables one mind to grasp and help speedily the difficulties and confusion of another, and the personal attraction which comes with winning ways. The investigator heeds *these* qualities in much less degree. A man, then, may be a good teacher without being a good investigator, and it would be unreasonable to expect all teachers to investigate. How are we to solve this apparent contradiction? It is necessary that the teacher should have some understanding of investigation. In order to have an understanding he should have taken part in such work, but on the contrary he may have neither the time nor the knowledge nor the the mental attributes to attempt profitably an undertaking so diffierent from that for which he has been trained.

It seems to me that the solution of this dilemma is not far to seek. If the teacher cannot himself conduct an investigation because of lack of time or aptitude of mental quality, he can at least gain much appreciation of the part played by research in the development of knowledge by reading to himself, and perhaps sometimes to his students, the classic researches of others in the domain of the physical sciences. When, for example, he proposes to bring before his students in the laboratory the study of chlorine, let him read the profoundly interesting original work of Davy. In this way his imagination will help him to appreciate the significance and relation of the phenomena to the rest of the fabric of chemistry. Fortunately, many of these classics of physical science are now to be had in republished form either among Harper's Scientific Memoirs, the Alembic Club series or the Klassiker der exacten Wissenschaften, and in any large city there are now files of the various chemical magazines in which other various fundamental articles are accessible. Those of

you who are in doubt about what to read will find suggestions in the various text-books of chemistry, for example, nt Walker's Introduction to Physical Chemistry, where occasionally the student is recommended to read this or that fundamental paper.

To those who have imagination, such reading alone will be a great help and stimulus, and will go far in aiding the teacher to present the subject to his pupils in the right proportions. In connection with the suggestion of reading the original papers, let me quote a few words which Ostwald has written upon this subject.

"Even today after almost a lifetime has elapsed I have not forgotten the impressions which I experienced when for the first time I enjoyed the pleasure of exploring the library of a chemical laboratory. Up to that time I had seen few books on chemistry, and not a single original treatise by one of our recognized masters. The reader can imagine with what wolfish hunger the young student, whose enthusiasm for his science had already been aroused, sat down to this sumptuous repast, and how ravenously, — though naturally without careful selection, — he devoured everything within his reach.

"At first as a result of my earlier training I read only text-books and monographs. But when I began my preparative work the professor, instead of allowing me to use mere receipts, directed me to look up in the volumes of the chemical journals the descriptions which the discoverers of the required substances had given of their original experiments. Accordingly I had to work through the researches of O. L. Erdmann, Laurent, von Baeyer and others on the products of the oxidation of indigo, and to prepare the corresponding compounds from their directions.

"My first impression was one of stupefaction, and when after some days I had read everything to be obtained upon the subject, I felt as if I had the millwheel in my head, which the student in Faust has described so well. Then, however, I returned to my experiments and preparations with renewed

vigor, and during the long pauses which necessarily accompany such work I read and re-read one research after the other and gradually obtained a clear conception of the subject, so that I still have a fair recollection of all its details.

"But above all, I learned on this occasion something far more important than the mere preparation of isatine and the other substances, something for which I owe my teacher a debt of gratitude which I shall never forget. I had learned that every scientific discovery is the result of a natural process of development, which leads through more or less numerous errors and misconceptions to a definite and lasting result. Until then I had not realized that a scientific truth is discovered by human agencies alone. I possessed, it is true, this theoretical knowledge, but the actual process of discovery seemed to me to verge on the miraculous; and that I might be able to make discoveries had never occured to me, my ambition was restricted to the possibility of some day being able to repeat the experiments of which I had read in the books. While the act of making a discovery appeared to be under the control of human forces, it was still very evident that only by the action of the most powerful forces could such a result be reached. To penetrate into and to understand the workings of these forces was for me a new and fascinating task, the zest for which was fostered and strengthened by my teacher." . . . .

"By following the scientific disputes of the past (and indeed no period has been free from these disputes), a kind of personal acquaintance with the character and manner of thought of the writers is involuntarily obtained along with a practical experience of the problems of science: two additions to the personal knowledge which must be valued very highly. The reader acquires a lively sense of scientific and of personal style; at times he is annoyed by the prolixity and vagueness of one writer, or pleased by the concise clearness of another, and endeavors to attain in his own works that which has been so pleasing in the works of others. In short

a large part of that gain which accompanies regular intercourse with talented and learned men, may be obtained by such an intimate acquaintance with a collection of old scientific journals. . . .

"As the giant of science retains the use of his strength only through contact with Mother Earth and becomes powerless when lifted into the airy regions of pure speculation, so in the same way the knowledge of science retains its true life in the mind of the individual only when it is continuously stimulated by immediate contact with the works of its great masters."

A few months ago I questioned Prof. Max Planck, the great German mathematical physicist, who was visiting Boston, concerning his views on this topic, telling him that I was to have the pleasure of addressing you today. He pointed out in addition to the arguments which I have already presented a further slightly different consideration which should perhaps be added to those already given. He said that to himself original papers were always far more suggestive and helpful than any subsequent compilation from them as regards the understanding of details of the particular subject, as well as more inspiring in their effect upon his outlook upon science as a whole. He thought the reason for this was because the mind which approached the subject for the first time viewed it in a different way from the mind which had already acquired a partial knowledge of it from others. The latter condition of mind is apt to assume occasional points as matters of course, whereas they may be by no means matters of course. We had just before been talking about the singular fact that it was left to a chemist to discover practically the great advantages of the atomic conception of material, although physicists have since used this conception with such enthusiasm in their more recent work. To Professor Planck this fact was an illustration of the way in which the detailed application of an idea, nowadays quite obvious to us, might by no means be obvious or a matter of course to a mind in

its unprepared condition; and he agreed with me in thinking that to really understand the atomic theory, even the physicist should read Dalton's first paper upon it.

So much for the reading of the classics of chemistry. Let me urge also the reading of original papers concerning some more recent line of research; for science is a living organism — from day to day it grows and develops new characteristics and new possibilities, as you very well know. In order to understand its growth, we must know something not only about its birth but also of its later development, and the mere perusal of the condensed text-book or desiccated abstract does not provide an adequate means for seeing or measuring the growth. Of course the literature of chemistry is now far too voluminous to make it possible for anyone to follow all; but would it not be worth while for every teacher to select some one line of research which especially interests him and which his training has fitted him to understand, and to read as many original papers as possible in this direction? Every forward looking teacher should take some good periodical, such as the "Journal of the American Chemical Society," as indeed, I know many of you do. I cannot too strongly emphasize the value of this method of keeping in touch with the chemistry of the present.

The attendance at scientific meetings also is valuable; but after all, such meetings serve but indirectly the advance of science. The limitations of time prevent the papers from being presented in full, and one obtains but a very partial view of any one research. Such meetings give an admirable opportunity for personal contact, and for the stimulus which comes from hearing the voice and looking into the face of others who are doing a part of the work of the world, and this opportunity I prize highly; but valuable as this personal knowledge may be, it cannot provide an adequate idea of the detailed steps through which new scientific knowledge is gained. Such an idea can be obtained only by the faithful study of the original communications in which the discoveries are set forth.

Thus far I have discussed chiefly the effect of research upon the teacher in relation to his pupil. Let me add also a word about the effect upon the teacher's own life and happiness. As President Eliot pointed out in his recent profound and stimulating address upon teaching as a career, in Sanders Theatre a few months ago, the effect of investigation upon the teacher himself is far-reaching. Our famous ex-president knew the college in the days when research was non-existent, and has brought it through the years to the time when research has become a dominant feature; and he expresses in emphatic terms his recognition of its vivifying effect upon its devotees.

"As American education is now institutionally organized, the first sort of position which offers itself to a young man looking forward to this career is that of the teacher in school, academy, normal school, college, university, or technical school — that is, in a great variety of teaching functions. I must insist again that this particular work, that of teaching in any of these institutions, has taken on, in recent times, a new aspect. The teacher today is not expected to be an impositor or expounder only. He is expected to be something more than a man learned in a subject. He is expected, of course, to be able to explain it and illustrate it with precision and enthusiasm; but he is expected to do something more than that. Wherever instruction is departmentally organized, — that is, in such a way that one teacher teaches one subject, — there the teacher is expected to be capable of advancing his subject, of winning a little bit of new truth from beyond the limit of present knowledge. The teacher is now-a-days expected to be capable of what we call research or investigation, or of making new groupings of facts, or new applications of the facts collected. This change in public expectation, this change in the demands which the profession makes upon itself, is a most happy and fortunate one. It lifts up the profession of teaching. It dignifies the occupation of the teacher. It makes it vastly more interesting. It

offers a new object of ambition to every teacher. He must learn the way to truth, the newly discovered way to truth, the scientific way, the way which is used in all fields of human knowledge, in all subjects of exploration and discovery. Every teacher should be so trained that he may possess this knowledge of the way to truth. And he must know this way that he may himself master some small portion of the field of human knowledge, and then creep a little bit beyond the present limits of that field. That single new expectation of the teacher has almost revolutionized the occupation quite within my memory."*

I quite agree with President Eliot. Learning instead of being, as of old, dry and formal, becomes imbued with new life. It is in a state of flux, growing, expanding, changing under one's hand, as the clay grows into spirituality under the hands of the sculptor. I agree with what Professor Minot has said in the quotation already read to you; there is no purer joy than this. Faraday in dreaming of wholly new relations and laws, was as much a creator as a poet or artist; and he had beside this joy of creation, the satisfaction of building his dreams upon the solid basis of firmly established nature. This enthusiasm born of a candid and penetrating search for truth cannot but influence the whole life of the investigator in all its relations.

Let us now review briefly the main argument, in conclusion of this brief address. In the first place we saw that research is of a very fundamental usefulness to humanity, that most of the arts and comforts and medical aid of modern civilization rest upon its foundation. This being the case, we were obliged to admit that the teacher should not be ignorant of its method or of its influence; for it is the noble office of the teacher to train the pupil's mind in all that which has to do with the growth of civilization. Further, because in order to understand any object of human endeavor one should take part in it, the teacher should have assisted in some original investigation himself, if possible. If circumstances prevent,

* Harvard Bulletin," May 5, 1909.

as they often must, the teacher must at least follow in imagination the researches of others. In carrying out this recommendation, he should read some of the classical *original papers* dealing with the fundamental facts and laws of his science, and should also keep pace with the advance in some special line of research which may interest him. The perusal of dry abstracts or concise compilations in best books will not serve this purpose; the original papers themselves must be thoughtfully read in order to enter into the spirit of investigation, as well as to understand the details of the particular subject being studied.

In conclusion, let me express to you my thanks for your interested attention.

The speakers of the afternoon on Industrial Chemistry presented their individual methods of teaching the topics under discussion. Many interesting points were brought out.

At the close of the afternoon session a vote of thanks was extended to Harvard University and to the speakers of the day.

The meeting adjourned at 4.30 P. M.

CHARLES W. GOODRICH, *Secretary.*

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New England Association

OF

Chemistry Teachers.

Report of the Thirty-Ninth Regular Meeting.

New England Association of Chemistry Teachers.

The thirty-ninth regular meeting of the Association was held Saturday, October 22, 1910, at Boston University, Boston, Mass.

PROGRAM.

9.15 A. M. Meeting of the Executive Committee.

9.30 A. M. Business Meeting.

1. Nomination of Officers.
2. Annual Report of the Treasurer.
3. Annual Report of the Secretary.
4. Report of the Committee on Current Events.
5. Report of the Committee on New Books. Review of Mr. R. P. Williams' "Essentials of Chemistry."
6. Election of Officers.

10.30 A. M. "The Experimental Basis of the Theory of Radio-activity."
Prof. H. W. Morse, Harvard University.

11.15 A. M. Some New Experiments.
Walter G. Whitman, Salem Normal School.

1. Analysis of Respired Air.
2. The Percentage of Carbon Monoxide in Illuminating Gas.
3. A Study of the Combustion of Iron in Oxygen.

11.45 A. M. "Some Phases of the German Chemical Industry."
Prof. Latham Clarke, Harvard University.

12.45 P. M. Adjournment.

The meeting was called to order by the President, Augustus Klock, at 9.30 A. M.

The appointment of a committee on nominations was followed by the Treasurer's report.

ANNUAL REPORT OF THE TREASURER.

RECEIPTS.

Balance on hand from 1911.....	$ 19.50	
4 Associate membership dues, 1909....	4.00	
5 Active membership dues, 1909.....	10.00	
68 Associate membership dues, 1910...	68.00	
63 Active membership dues, 1910.....	126.00	
Food Chemistry Course.....	44.00	
		$271.50

EXPENDITURES.

Envelopes, stamps, stationery.....	$ 28.86	
3½ Reports (one from 1909).....	144.45	
Printing, other than reports.....	9.75	
American Federation of Science and Math.	15.90	
Food Chemistry (Hall, printing, etc.)..	38.42	
		$237.38
Balance on hand		$34.12

Respectfully submitted,

ALFRED M. BUTLER, Treasurer.

ANNUAL REPORT OF THE SECRETARY.

The thirty-sixth meeting of the Association was held at Harvard University on December 4, 1909. After the reports of the standing committees the election of officers was held. Ostwald and Morse's "Elementary Modern Chemistry," Emery's "Elementary Chemistry" and Segerblom's "First Year Chemistry" were reviewed. Mr. L. G. Smith spoke on "Some Experiences of an American Teacher in the German Higher Schools. Prof. T. W. Richards' address was on "The Value of Investigation to the Teacher of Chemistry."

The thirty-seventh meeting was held at the Lowell Textile School on February 12, 1910. The morning was spent in observing the equipment and the methods employed in the teaching of textile chemistry. At the afternoon session Prof. Olney gave a very interesting talk on the work of the school. Godfrey's "Elementary Chemistry" and Biltz's "Introduction to Experimental Inorganic Chemistry" were reviewed. The report of the delegates to the American Federation meetings was made by Wilhelm Segerblom. Professor Newell presented the report of the Committee on Current Events.

The thirty-eighth meeting was held at the Harvard Medical School on April 16, 1910. The meeting opened with the reports of the various standing committees. Under new business Mr. Segerblom called attention to the American Federation report in "School Science and Mathematics." Attention was also called to the fact that delegates had been appointed by the Federation to consider the possibility of changing the College Entrance Board Chemistry syllabus. The principal address of the day was on "The Function of Enzymes in the Chemistry of Life," by Dr. A. W. Peters. This was followed by a short address by Dr. C. A. Scott on "The Psychology of Science Teaching." The laboratories of the Medical School were visited at the close of the morning session. The afternoon was spent at the Carnegie Nutrition Laboratory, where Mr. Carpenter, the chemist in charge, described the laboratory and its special apparatus.

Through the kindness of President A. Lawrence Lowell, a course on the Chemistry of Food" was given by Prof. A. G. Woodman.

The membership of the Association is at present as follows: Honorary, 17; active, 69; associate, 87; making a total of 169. Four members are counted both as honorary and as active members. Two of our members died during the year: Miss Minnie G. Farwell and Linwood O. Towne.

On account of the sentiment expressed at the last annual meeting, the reports have been made shorter and valuable material has often been crowded out.

All members are urged to help in securing new members, either by notifying the secretary of new teachers, or by personally presenting the matter to such teachers.

Respectfully submitted,

CHARLES W. GOODRICH,
Waltham, Mass.

REPORT OF THE COMMITEE ON CURRENT EVENTS.

The following report was read by the chairman, Prof. Lyman C. Newell:

CANNIZZARO. This famous Italian chemist died May 10, 1910. Obituary notices can be found in Nature, May 19, 1910; Science Progress, V. 147; Journal of the American Chemical Society, August, 1910 (Proceedings, page 97); American Chemical Journal, October, 1910, page 384. An early account of his work is in Nature, May 6, 1897; the same article is reprinted in the last edition of Thorpe's Essays in Historical Chemistry.

RADIUM. The daily press reports the isolation of metallic radium by Mme. Curie and M. Debierne. Its properties, as far as could be observed, resemble those of barium. Prof. Kammerling Onnes of Leyden has placed his cryogenic laboratory at the disposal of Mme. Curie for her study of radio-activity at low temperatures. Sir William Ramsay recently announced

that over half a gram of pure radium (or 5,500 milligrams of ten per cent. radium) has been extracted from the Cornish pitchblende obtained from the Trenwith mine at St. Ives. The radium is "stored at the factory in a specially constructed safe lined with lead and asbestos." (Science, November 18, 1910, page 714.) An excellent summary of "radium to date" can be found in the new volumes of the Century Dictionary under Radium.

Artificial Camphor. In a monograph on the camphor industry in foreign countries, issued by the Bureau of Manufactures, Department of Commerce and Labor, are given reports from American consular offices on the production of natural camphor in Japan, Formosa, Borneo and Ceylon, and the competitive manufacture of synthetic camphor in Germany. The pamphlet describes the preparation of camphor from the wood of camphor trees, the principal sources of supply, and the various methods of producing synthetic camphor. Reference is also made to the extent of the camphor trade and the influence of the synthetic product on the price of natural camphor. Copies of this pamphlet can be obtained free by writing to the Secretary of the Department of Commerce and Labor. See also Merck's Report, 13, 42, and Journal American Chemical Society, April, 1904, page 175.

Welsbach Mantles. An illustrated pamphlet, describing the making of a mantle, can be obtained free at the Welsbach store, 24 Summer street, Boston, Mass. A fuller account is in Journal Engineering and Industrial Chemistry, April, 1909, page 235.

REPORT OF THE COMMITTEE ON NEW BOOKS.

George A. Cowen, *Chairman.*

Essentials of Chemistry. By Rufus Phillips Williams. Ginn & Co., Boston, Mass. Reviewed by George A. Cowen.

This book embodies many new and commendable features. The experiments are arranged in chapters by themselves, and in all cases the experimental comes before the descriptive

chapter. Carefully graded questions, printed in bold type, accompany the laboratory exercises, to aid the pupil when writing up his notes, to observe the most important phenomena. There are about 250 experiments, many of which are originals to be worked out by the pupil independently, but these are not of such a nature as to discourage the thoughtful student. The number of quantitative and qualitative exercises is well chosen.

The chapters on theory are written in such a manner as to be easily understood, but in no case has scientific accuracy been sacrificed to secure simplicity.

The illustrations are good, showing accurately the arrangement of the apparatus, or making clear the theory or the commercial process under consideration.

Commercial and manufacturing chemistry is treated rather more fully than in the ordinary text-book.

There are two chapters on organic compounds. It will be found a book alike helpful to teacher and pupil.

The Chemist's Pocket Manual. By Richard K. Meade. The Chemical Publishing Company, Easton, Pennsylvania. 456 pages. 39 illustrations. $3.00. Reviewed by W. Segerblom.

As the title indicates this is a practical handbook, containing tables, formulas, calculations, information, physical and analytical methods for the use of chemists, engineers, assayers, metallurgists, manufacturers and students. In this second edition the text has been revised and much enlarged by the addition of analytical methods. The author's aim has been to present in condensed form information of interest to plant chemists and chemical engineers. The book contains much matter which might interest pure chemists, such as standardizing weights, calibration of chemical glass ware, making and standardizing of volumetric solutions, indicators and test papers. The 150 pages of condensed matter on methods of technical analysis of iron, steel, slags, alloys, coal, fuel gases, water, cement, limestone, fire-clay, lubricating oil, soap, paints, organic substances and the ores of iron, copper, lead and zinc

should give a good bird's-eye view of these processes to such chemists as have not the time to use the larger works on these subjects.

After the report of the committee on nominations had been accepted, the Association proceeded to elect by ballot officers for the year 1910-1911, with the following results:—

President, FREDERICK C. ADAMS, Mechanic Arts High School, Boston, Mass.

Vice-President, CHARLES W. GOODRICH, Waltham High School.

Secretary, EDWARD S. BRYANT, Everett High School.

Treasurer, ALFRED M. BUTLER, East Boston High School.

Executive Committee, FRED L. BARDWELL, Massachusetts Institute of Technology; HAROLD BISBEE, Dorchester High School; GEORGE A. COWEN, West Roxbury High School.

It was voted on motion by Mr. Adams that the Executive Committee take the steps necessary to incorporate the Association.

It was voted to make Boston University the repository and Professor Newell the Curator of all gifts to the Association,—books, apparatus, specimens, lantern slides, etc.,—and that these articles be lent to members on request whenever possible.

Prof. H. W. Morse of Harvard University made the opening address, speaking as follows on "The Experimental Basis of the Theory of Radio-activity":

Becquerel's "Uranium Rays" started the search after radio-active elements. Schmidt and Mme. Curie found activity in Thorium compounds, and the two Curies followed the activity in Uranium minerals until they found "Radium."

At the same time our knowledge of the conduction of electricity through gases gave us the

"alpha ray," a charged atom,

"beta ray," the electron,

"gamma ray," the X-ray, which starts when an electron is suddenly stopped.

It was found that the radio-active substances gave off similar

rays. The study of the radio-active elements has been made possible by measurements made on these strange radiations,

Before the study of the active elements found in pitchblende had gone very far, what have been called *emanations* were found. An emanation is a true gas, which can be bubbled through water or cotton wool and which may be very active indeed. The emanation from Thorium was found to be very active at first, and to lose this property rapidly. The Radium emanation decays more slowly. The activities are as usual measured by the electroscope. It was found that the rate of decay of an emanation is unchanged by any physical or chemical agency whatever. It is the same at $+450°$ and at $-180°$. The emanation from another active substance called "Actinium" decays more rapidly even than Thorium, and its activity falls to one-half in 3.9 seconds.

Before long, study of the rates of decay showed that there was an intermediate substance between Thorium and the Thorium emanation, and this was called "Thorium X." Radium shows no such intermediate step. The emanations show characteristic spectra and condense at liquid air temperatures. This past summer Ramsey and Gray have succeeded in getting two or three cubic millimeters of Radium emanation and they have determined its density. It seems to be a very heavy gas of molecular weight over 220.

As the emanations decay they leave behind them radio-active deposits, which can be collected on wire or dissolved in acids and concentrated by evaporation. Study of these phenomena of "excited radio-activity" has shown pretty clear evidence of the following steps in the decay of Radium and Thorium:—

Ra—} RaEm—} Ra A —} Ra B—} Ra C—} Ra D.
Th—} Th X—} Th Em—} Th A—} Th B—} Th C.

It seems very probable that Radium has been produced from Uranium. Radium has a fairly long life, breaking up to the extent of 0.5 mg per year per gram. Its activity decays to half in about thirteen hundred years.

Each alpha particle given off during the decay of Radium and its successors seems to be an atom of Helium. After the whole series of steps has been passed it seems to be true that Radium has broken up into Helium and a heavy, non-radioactive element, perhaps Lead.

Mr. Walter G. Whitman of the Salem Normal School described three interesting new experiments.

I. ANALYSIS OF RESPIRED AIR.

The purpose of this exercise is to determine the chief constituents of respired air and the approximate percentage of each.

Water Vapor.—Exhale two or three full breaths through a glass tube that extends to the bottom of a dry test tube. Explain why the exhaled air loses so much water by condensation. The exhaled air when cooled to room temperature is still saturated. By reference charts or tables showing the amount of water vapor required to saturate air at different temperatures it is found that at 70° F. the air must contain about one per cent. water by volume.

Carbon Dioxide.—The presence of carbon dioxide may be shown by blowing through lime water. A white precipitate shows carbon dioxide to be present. The percentage of carbon dioxide may be determined as follows: A 300 cc. wide-mouth bottle is filled with respired air by blowing through a glass tube which extends to the bottom of the bottle. Exhale at least four full breaths into the bottle, withdrawing the glass tube just before finishing blowing. Cover the bottle with a piece of glass or paper. Fill a 250 cc. Florence flask in the same manner and place it mouth down in the bottle of respired air. Allow to stand for ten minutes to cool to temperature of room. Explain why the flask is placed in the bottle. Record room temperature and barometer reading. Measure out 50 cc. sodium hydroxide solution (40 grams to 100 cc.) into a 100 cc. beaker. Transfer the flask of respired air to the beaker, placing it mouth down in the solution, taking care

not to handle the flask with the bare hand. (The heat that may be imparted to the flask by the hand will cause expansion of the gas and seriously affect the results.) A few thicknesses of paper or cloth should separate the fingers from the flask. After 24 hours adjust the levels of the liquids, observing the same precaution as before. Mark the level. The volume of liquid in the neck of the flask represents the volume of carbon dioxide. Devise a way in which to measure this volume. Also measure the volume of the flask. Why? Read the barometer and take the temperature of the room. Make a rough calculation of the percentage of carbon dioxide without correcting the volumes. If more accurate results are desired, correct the volumes for temperature, pressure, and aqueous tension.

Oxygen.—The percentage of oxygen is determined by dissolving both carbon dioxide and oxygen in an alkaline pyrogallate solution. The percentage of carbon dioxide is subtracted from the percentage of carbon dioxide and oxygen, to get the percentage of oxygen. A test tube is filled with respired air in the same way in which the flask was filled. After cooling to room temperature, it is placed mouth down in a beaker containing a mixture of 25 cc. concentrated solution of sodium hydroxide with 25 cc. of a solution of pyrogallic acid (10 grams to 100 cc.). Allow to stand for 24 hours. Measure volumes and calculate the percentage of oxygen.

Nitrogen.—The balance of gas unabsorbed in the preceding experiment is impure nitrogen.

The percentage composition of respired air as found in this experiment is:

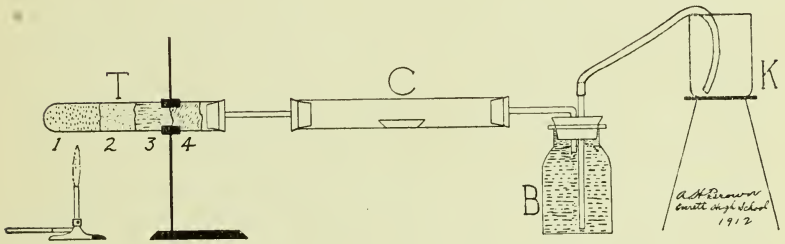
Moisture	%
Carbon dioxide	%
Oxygen	%
Nitrogen (Impure)	%
	100 %

II. THE PERCENTAGE OR CARBON MONOXIDE IN ILLUMINATING GAS.

The carbon monoxide is absorbed by a solution of cuprous chloride* (CuCl) which leaves the other constituents of the gas unchanged. A test tube full of gas is inverted in a beaker containing the cuprous chloride solution, fastened upright, and left over night. The volume of liquid that enters the tube represents the carbon monoxide dissolved out of the illuminating gas. If the temperature and pressure of the air change much during the progress of this experiment, it is advisable to make corrections for temperature, pressure, and aqueous tension.

* 5gms $CuCl_2$ are dissolved in 25 cc. con. HCl and 25 cc. water added.

III. A STUDY OF THE COMBUSTION OF IRON IN OXYGEN.



T A long test-tube containing:

1. "Oxygen mixture" (5gms each of $KClO_3$ crystals and MnO_2 powdered).
2. Asbestos wool.
3. Fused calcium chloride.
4. Asbestos wool.

C Combustion tube, holding a porcelain boat which is nearly full of iron powder. (Iron by hydrogen.)

B A 250 cc. wide-mouth bottle, nearly full of water.

K A 300 cc. beaker elevated upon a tripod or other support.

After weighing the porcelain boat and contained iron powder by means of a chemical balance, assemble the apparatus and materials as shown in the diagram. All connections must be air-tight. Test connections by blowing through the rubber tube coming from B until a few bubbles pass into B. If now on releasing the tube, water rises and remains in the glass tube, the apparatus is air-tight.

Heat the oxygen mixture gently, generating a slow current of oxygen. (Take care not to heat that part of the tube where the calcium chloride is; for if moisture is carried over to the combustion tube it decreases the intensity of the action.) Continue to generate oxygen for a few seconds after the gas begins to escape through K. Allow to cool until no more bubbles of oxygen come out of the water in K.

Apply the flame, very cautiously at first, to the combustion tube about the porcelain boat. When the tube is warmed so that there is no danger of cracking it, apply very strong heat. Look for evidence of chemical action in the boat while heating. Observe any change which may occur in bottle B. After the action seems to have been completed lower the flame and gradually cool the tube. When cold weigh the boat and contents. Account for the change in weight and color. Write the equation for the reaction. In a brief summary state a conclusion drawn from evidence observed in this exercise, and enumerate all points of evidence that support your conclusion.

Record as follows:—

Weight of boat and contents before heating .....
" " " " " after " .....
Gain or loss in weight .....

Dr. Latham Clarke of Harvard University gave a very interesting talk on "Some Phases of the German Chemical Industry." He declared that in his opinion the most striking phase of the German chemical industry today is "its almost complete utilization of by-products and waste energy." Taking as an illustration of this characteristic a single concrete example, Dr. Clarke described a new process for the manufacture of liquid carbon dioxide, and illustrating the details by rapid sketches on the blackboard outlined a process in which it seemed that ingenuity and thrift could go no further.

At the close of the meeting a vote of thanks was extended to the speakers of the day.

The meeting adjourned at 1 P. M.

EDWARD S. BRYANT, *Secretary*,
24 High Street, Everett, Mass.

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NEW
No. 42
1911

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS

Forty-Second Regular Meeting

Saturday, November 11, 1911
At the Physics Laboratory of Boston University
Boylston Street, Boston

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PROGRAM.

Morning Session.

9.45 *A. M.*
Meeting of the Executive Committee.

10.00 *A. M.*
Business Meeting.
1. Election of New Members.
2. Nomination of Officers.
3. Annual Report of the Treasurer.
4. Annual Report of the Secretary.

10.15 *A. M.*
"The Electron Theory," its Fundamental Conceptions and its Applications to Chemistry, illustrated by several experiments.
PROFESSOR NORTON A. KENT, Ph.D., of Boston University.

11.15 *A. M.*
"In Memoriam" of RUFUS PHILLIPS WILLIAMS, President, N. E. A. C. T., 1900-1902.

11.30 *A. M.*
1. Report of the Committee on New Apparatus.
MR. ALFRED M. BUTLER, Chairman.
2. Report of the Committee on Current Events.
PROF. LYMAN C. NEWELL, Chairman.
3. Report of the Committee on New Books.
MR. GEORGE A. COWEN, Chairman.
"Elementary Chemistry," by MORGAN and LYMAN.
"Introduction to General Science," by ROWELL.
"Sanitary and Applied Chemistry," by BAILEY.
"Chemistry of Food and Nutrition," by SHERMAN.
4. Report of the Curator. PROF. NEWELL.

12.15 *P. M.*
Intermission.

Afternoon Session.

1:30 *P. M.*
Business Meeting.
Election of Officers.

2.00 *P. M.*
Lecture and Demonstration on "The Thermit Process" and its Applications to Welding, Reviving, and Purifying Iron and Steel and the Production of Metals and Alloys free from Carbon,—illustrated by lantern slides, specimens, and experiments on the lecture table.
MR. W. R. HULBERT, representing the Goldschmidt Thermit Company of New York.

3.15 *P. M.* Adjournment.

The Executive Committee recommends the following candidates for membership in the Association:

For Active Membership.

Mr. S. Walter Hoyt, Mechanic Arts High School, Boston.
(An associate member since 1906)
Mr. Irving H. Upton, Roxbury High School, Boston.

For Associate Membership.

Mr. Gilman H. Campbell, High School, Natick, Mass.
Mr. George Willis Day, Classical High School, Lynn, Mass.
Miss Elizabeth S. Hacker, High School, Everett, Mass.

ANNUAL MEETING.

The meeting was called to order by Frederick C. Adams, retiring president, and business taken up. The applicants for membership, whose names appear on the program, were unanimously elected. By unanimous vote the reading of reports of the secretary and treasurer were put over to the afternoon session. It was voted that the president appoint a nominating committee of three to present at the afternoon meeting a list of nominations to be voted on, at least two for each office.

Professor Norton A. Kent Ph.D., of Boston University then delivered the following lecture on "The Electron Theory."

THE ELECTRON THEORY.

By the electron theory is meant that theory which aims to reduce the phenomena of all Physics, particularly in the realm of electricity and magnetism to the distribution and motion of small particles called electrons.

The chief steps in the later development of this theory were the discovery of (A) Cathode, (B) Röntgen and (C) Becquerel Rays.

(A) The Cathode rays were discovered in 1869 by Hittorf while working upon the discharge of electricity through high vacua. These rays were found by him to suffer deviation in a magnetic field; and, later, other investigators showed that they could be deviated by an electrostatic field also, and, that they consisted of small particles traveling with high velocity. The determination of their velocity was made by J. J. Thomson in 1897, one of his methods being as follows:—The rays were caused to pass through a magnetic field horizontally in such a way that they were deflected, for instance, downward, this being accomplished by their subjection to horizontal lines of magnetic force directed normal to their path. Further, a vertical electrostatic field was established and its strength and direction were made such as to exactly counterbalance the deflection of the magnetic field. Under these conditions data were obtained from which could be calculated the velocity of the particles forming the rays. This method also gave at the same time a value of e/m or the ratio of the electrostatic charge carried to the mass of the carrier.

In this same year C. T. R. Wilson performed his famous cloud condensation experiment from which an approximate value of "e" was obtained: whence followed the value of "m". From

these and other experiments the remarkable conclusions were drawn that (1) the velocity is very high, almost 1-10 the velocity of light in some cases, (2) the apparent mass of the carrier or "ion" is the same whatever gas be used in the tube and (3) the charge carried is negative.

The values of these constants furnished by the best modern determinations are:—

Velocity = 2.8 10^9 cm/sec.
Apparent mass = 1/1770 of the mass of the hydrogen atom.
= 8. 10^{-28} grams.
Charge carried = 4.69. 10^{-10} c.g.s.e.s. units.

Various other phenomena which are present in vacuum tubes lead us to believe that other carriers of electricity exist which are of the size of atoms and groups of atoms—these classes of ions carrying a positive charge.

(B) The Röntgen rays were discovered in 1895 by Röntgen, while working with the Cathode rays. He found that in a certain region outside the vacuum tube a powerful radiation existed. This was later shown to be what is called an ether pulse, a disturbance in the ether resembling light in some of its characteristics. Within the last few years research upon research has followed with tremendous rapidity, many of these showing that the title, "Ionic Theory," might well be substituted for "Electron Theory" for, while the negative ion, the electron, is generally the more important, the positive ion also must be considered as playing a vital part.

(C) The Becquerel rays were discovered in 1896 by Henri Becquerel, who was studying the effect of certain uranium compounds upon a photographic plate after they had been subjected to sunlight. As chance would have it the weather was cloudy for some days and Becquerel was prevented from performing the experiment as intended. He thought, however, that it would be interesting to see if any action had resulted on the plate which had been lying in its plate holder under the compound pending exposure to the sun. He, therefore, developed it and, to his astonishment, found that it showed an effect, proving that the sun's rays were not necessary and that the substance was itself, capable of emitting radiations which would affect silver salts.

Monsieur and Madame Curie then followed with other experiments and the latter finally succeeded in isolating an element, radium, which possesses, to a very high degree, this power of emitting Becquerel rays. We now know that radium is but one of a group of radioactive elements which are continually and spontaneously undergoing disintegration. In so doing they emit

positively charged particles, called "α" particles, negatively charged particles, electrons, called "β" particles and generate thereby ether pulses called "γ" rays, which last are none other than Röntgen rays. The Cathode or "β" *rays* should be called the Cathode or "β" *stream* and the "α" rays, the "α" stream—both the α and β emissions being distinctly different in their nature from the γ or Röntgen rays.

The applications of the electron theory which will be of most interest to the chemist are possibly those dealing with (a) valence and the periodic variation of the chemical properties of the elements with their atomic weight and (b) the phenomena accompanying solution and the conductivity of electrolytes. As discussions preliminary to these two groups of subjects we will take up for (a) J. J. Thomson's theory of the architecture of the atom and for (b) the phenomena of metallic conduction.

(a) Professor Thomson's theory* of atomic structure postulates the existence of successive rings of electrons moving about a common center within a so-called "sphere of positive electrification." The number of electrons in each ring has been discussed by him and the relative stability of configuration has been mathematically investigated.

The main results are: stability can exist when electrons numbering 1 to 5 (inclusive) form a ring, but if 6 be present the equilibrium is unstable and the sixth passes to the center forming a new arrangement or configuration—5 electrons revolving about one in the center. Then 1, 2 or 3 may be added to the outer ring, but when 4 are added one more goes to the center (making 2 within 8) etc. For instance: the group of stable configurations for from 1 to 31 electrons are as follows:—

1	2	3	4	5											
5	6	7	8	8	8	9	10	10	10	11.					
1	1	1	1	2	3	3	3	4	5	5.					
11	11	11	12	12	12	13	13	13	13	13	14	14	15	15.	
5	6	7	7	8	8	8	8	9	10	10	10	10	10	11.	
1	1	1	1	1	2	2	3	3	3	4	4	5	5	5.	

The first, second and third groups form one, two, and three ring systems. On some such structure as this lies the basis for the truth of the periodic law. For instance: let us start with an element such as lithium, pass on, in the Mendeleeff table, by many elements which do not resemble lithium, until finally we reach sodium which has many properties in common with lithium; and so on to potassium. This periodicity is just what

* J. J. Thomson, The Corpuscular Theory of Matter, Chapter VI.

it would be if the atoms contained numbers of electrons proportional to their atomic weight, they being arranged according to some such scheme as Professor Thomson has outlined. Further, the addition or subtraction of an electron produces greater change at some times than at others. In short, as a result of this variation in stability of the different configurations Professor Thomson has shown that the ease with which an atom of any stable structure will seize upon or give up an electron and so reach a more stable configuration varies in such a way that the number of electrons which it can lose plus the number which it can gain always equals a constant, 8 in the case discussed by him. Atoms can then supposedly exist which have the valences ranging from +0 to —8 and —0 to +8: thus, if we indicate the electro-positive valence or tendency to lose electrons by + and the electro-negative or tendency to gain electrons by —, the possible combinations are:

Total number of electrons in various rings	59	60	61	62	63	64	65	66	67
Valence	+0	+1	+2	+3	+4	—3	—2	—1	—0
	—8	—7	—6	—5	—4	+5	+6	+7	+8

and the sums of the electro-positive and electro-negative valences equal 8. It is, however, purely a coincidence that the atoms discussed by Professor Thomson give the number 8, that number which actually exists in nature.

Take the double series of elements:—

He. Li. Be. B. C. N. O. F. Ne.

Ne. Na. Mg. Al. Si. P. S. Cl. Arg.

"The first and last element in each of these series has no valence, the second is a monovalent electro-positive element, the last but one a monovalent electro-negative element, the third is a divalent electro-positive element, the last but two a divalent electro-negative element, and so on."

As examples of molecules in which there occur certain atoms which have variable valence we may cite:

Carbon, $\begin{cases} C\,Cl_4 & +4 \\ C\,H_4\,* & -4 \end{cases}$ Sulphur, $\begin{cases} So_3 & +6 \\ H_2\,S & -2 \end{cases}$

Phosphorus, $\begin{cases} P\,Cl_5 & +5 \\ P\,H_3\,* & -3 \end{cases}$ Iodine, $\begin{cases} I_2\,O_7 & +7 \\ H\,I & -1 \end{cases}$

In conclusion we may briefly mention a few facts which are just those which we would expect on the basis of this theory.

1. There exist different degrees of combining power such that elements can be arranged in an "electromotive series."

2. The heaviest atoms are the most electro-positive, losing electrons with greatest facility.

* In the light of the electron theory we might suggest to the chemist that $C\,H_4$ and $P\,H_3$ be written H_4C and H_3P respectively.

3. Chemical action always tends toward a reduction of the number of valence electrons in one combining atom to 0 while raising those in the other to 8.

4. In the case of O, H and Cl which form molecules of two atoms each, one atom gains an electron and the other loses it. They are thus able to form with other atoms molecules in which they are in certain cases electro-positive and in others electro-negative.

5. Other atoms which are inert (e. g. helium) and those which are always electro-positive always exist in monatomic form.

These results are certainly startling. It is very probable that the successive rings of electrons do not in nature lie in one and the same plane, but the difficulty of mathematical treatment of any other system is at present so great as to make the problem an unsolved one on any other supposition than that of a common plane.

(b) As a preliminary to the second group of subjects, the conductivity of solutions, we shall discuss the theory of metallic condition. Metals are characterized by the fact that at all times there are a considerable number of electrons which are more or less free (these being indeed the valence electrons) and which, when subject to electrostatic forces, are easily urged from atom to atom, thus constituting a current, the direction of this electric current, however, being opposite to that of a "current" in the ordinary sense. Non-conductors of electricity are supposed, on the other hand, to have few free electrons, this explaining their dielectic properties.

In electrolytes then we might expect to find that electrons are involved and they indeed are, but in a slightly different manner. Upon solution of the salt of a metal in some solvent—$CaCl_2$ in water, for instance—the force of attraction between the electro-positive and the electro-negative elements is weakened in proportion to the specific inductive capacity of the solvent, and they fall apart or "are ionized" by solution. But the ions are, in this case, (1) the atoms of the electro-positive element calcium (being electro-positive because they are short two electrons each) and (2), the atoms of chlorine (electro-negative as they each possess one excess electron). If, then, an E. M. F. be impressed upon two terminals immersed in the solution, these two sets of ions will move—one set, the calcium, each carrying a double + charge, toward the cathode and the other, the chlorine, each carrying a single — charge, toward the anode. The electrons are here towing the chlorine atoms while the calcium atoms, deficient in electrons, and being as we say, "positively charged," also move in the electrostatic field.

But it is in the field of Physics proper that the electron theory finds its most extensive use in unifying and rendering more simple our conceptions of the processes of nature. A few of these may be briefly cited.

(1) The creation of Röntgen rays by the cathode stream: cathode particles impinging upon the positive electrode, or some other obstruction in the tube, and thus being suddenly arrested in their motion set up pulses in the ether which constitute the Röntgen rays.

(2) The phenomena of the electric discharge: (A) the arc, (B) the spark.

(A) After the carbon terminals of the arc are brought together the flow of electrons heats the terminals and vaporizes some of the carbon or metallic impurities. When the terminals are then drawn apart the current continues to flow and more vapor is furnished by the bombardment of the carriers of the current—particularly the positive ions—set in motion by the electrostatic forces of the field, which keep the terminals so hot that they in turn furnish ions and produce ionization of the gases between them.

(B) The phenomena are very similar in the case of the spark, the main difference being that in the spark the difference of potential is so high that any free ions which happen to exist in the air or the gas between the terminals are urged to move with such rapidity that they cause further ionization of the molecules of the gas and finally of the metal forming the terminals themselves.

By ionization, in the physical, not chemical, use of the term, we mean a splitting up of the neutral atom into one or more electrons and a positive ion usually of atomic size.

That the discharge in the case of the arc and spark is a convective process in which ions take part may be shown by the fact that the arc and spark can be blown out, as it were, by placing a magnet near the terminals.

(3) The entire phenomenon of the spectra of various substances is easily explained on the supposition of ions and positively charged carriers in the source of illumination, whether flame or electric arc or spark. It is these charged particles which, vibrating with their own characteristic frequencies, lay hold upon the ether and send out ether waves of various wave-length, the lines in the spectrum being nothing but images of the slit of the spectroscope in the light of these different wave-lengths. And further, the fact that in spectra there exist beautiful groups of lines forming the so-called line and band series, the wave-lengths of the individual lines of which bear a certain mathematical relationship, is exactly what we would expect to follow from the

presence of ions vibrating according to harmonic laws, giving a fundamental and overtones as in the case of sound—precisely what we would expect from an atom constructed on some such plan as Professor Thomson has outlined.

(4) The result of placing the source of light in the magnetic field giving the so-called Zeeman effect points clearly to the fact that within the source of light there are vibrating carriers—in this case electrons—the frequency of vibration of which is altered by the magnetic field, resulting in the doubling, tripling, quadrupling, etc., of the individual lines of the spectra.

(5) The explanation of the Faraday, Kerr and Macaluso-Corbino effects, consisting of various influences of the magnetic field upon light waves, follow directly from the electron theory.

(6) The Hall effect, discovered by Professor Hall of Harvard, is of considerable interest. If a wire be connected to one end of a sheet of metal, for instance gold leaf, and another wire to the other end, and a current be passed through the system, the lines of flow of the current will resemble those of the flow of water passing from a stream into a lake and again from the lake into a stream. If, however, this sheet of foil be placed in a magnetic field perpendicular to its lines of force, the lines of current flow will be distorted, a direct result of the fact that the electrons are more mobile than the larger positive ions. Modifications of this principle, dealing with the interaction between the current stream, magnetic lines of force and heat currents lead to further phenomena — the so-called Leduc, Nernst and Von Ettingshausen effects.

(7) All the phenomena of the vacuum tube fall into line with great ease: (a) The Lenard rays, discovered by Lenard and shown by him to be nothing but the cathode stream outside the tube, the electrons having passed through a thin window of aluminum foil; (b) the canal rays, a stream of positively charged particles apparent behind a cathode through which holes have been bored; and (c), as mentioned above, the development of the Röntgen ray by the sudden arrest of the motion of the electron.

(8) Ionization, or the removal of electrons from atoms, can be accomplished in various ways: for instance, by Röntgen rays, ultra-violet light, radioactive elements, and the emission of electrons and positive ions from hot metals. In the case of the Röntgen rays the shattering of the ether pulse will easily explain the removal of the electron from the atom of the gas through which the ray is passing. A similar result is produced by light waves of short wave-length, those of ultra-violet light; and in the case of the radio-active elements we suppose that the emission of electrons, the β stream and positively charged particles, the "α"

stream, and the development of the Röntgen or "γ" rays are all responsible, each in its own measure, for the ionizing effect. Finally, when a hot metal is heated to incandescence either by a flame or an electric current, ions are ejected and ionize the surrounding gas.

There also exists a special case of ionization by ultra-violet light called the "photoelectric effect." When light of short wavelength falls upon certain metals, particularly zinc, electrons are emitted by the metal. This may result in a gain of a positive charge by an uncharged metal, if we blow the electrons off as they are released, or, if the metal be charged negatively, the loss of its charge may follow under the action of the rays.

(9) If one substance be brought in contact with, or rubbed over, another substance—a piece of silk over a glass rod, for instance—as the electrons have a greater affinity for the silk than for the glass, the result is that some escape to the silk, leaving the glass in a state of positive electrification, the atoms and molecules of the latter being deprived of part of their electrons.

The scope of this paper renders impossible an exhaustive application of this theory. Many phenomena, however, other than those cited, can be explained by it—notably those of electric inertia, the dispersion of light, absorption spectra (a case of resonance in light), the development of electromagnetic waves, the Peltier, Thomson and Seebeck effects, and such cosmical phenomena as a daily variation in the earth's magnetic field, the gegenschein, aurorae, the solar corona and magnetic storms. Further, the field of the theory is constantly widening and no one can now predict what the future has in store for the scientific world.

Following this Professor Lyman C. Newell presented an appreciation of our former President, Rufus P. Williams, whose death occurred recently.

RUFUS PHILLIPS WILLIAMS: AN APPRECIATION.

Rufus Phillips Williams died at his home in Cambridge, Mass., August 23, 1911. Mr. Williams was born in 1851 at Ashfield, Mass. He graduated from Dartmouth College in 1876 with the degree of A. B. Three years later he received the degree of A. M. from the same institution, though he had already won this degree from Harvard College for special work in science. In 1885 Mr. Williams was appointed teacher of chemistry in the English High School, Boston, Mass., and retained this position until his death. He married Lillian Walker of Boston in 1894, who survives him.

Mr. Williams taught chemistry for twenty-five years, and sev-

eral thousand boys came under his personal supervision. As a teacher he not only had the power to view the subject from the boy's standpoint but he also possessed the skill to present his thoughts in simple language. Moreover, he gave personal service without stint, and many graduates of the English High School have spoken in later life with admiration of the direct and wholesome influence of this faithful teacher. As an author, Mr. Williams was industrious. He wrote eight books on his chosen subject—three texts and five laboratory manuals. These books, which have always been widely used, were written in the convincing language that characterized his oral style. Mr. Williams especially deserves the highest praise for making inexpensive laboratory manuals; this plan involved sacrifice on his part, but it enabled many schools having few pupils to study chemistry by experiment—the only rational way.

When "School Science" was established Mr. Williams was selected as one of the Associate Editors and given charge of the Department of Metrology; later he became a Departmental Editor of "School Science and Mathematics." He had a contribution in nearly every issue of this magazine up to his last illness. Many of these articles have permanent value, notably the longer one entitled, "The Planting of Chemistry in America."

Mr. Williams shared the labors and enjoyed the privileges of scientific societies. In addition to the larger organizations, he served especially two local associations—the Agassiz Association and the New England Association of Chemistry Teachers. He was president of the Massachusetts State Assembly of the Agassiz Association during 1891-1892, and president of the local chapter for four years. When the New England Association of Chemistry Teachers was established in 1898, he attended the meeting called for organization and was one of the charter members. He was president during 1900 and 1901. Merely to enumerate the offices he held with such dignity and the committees on which he served with such insight might indicate his activity, but it would give no adequate statement of our appreciation of his wise counsel, faithful attendance, indefatigable labor, unwavering honesty and sterling integrity.

This is a brief record of the life and labors of Mr. Williams. Two aspects of his relation to us deserve at this time, our formal recognition—his sympathetic co-operation as a teacher of chemistry, and his unselfish devotion to our Association. And, as chairman of this committee, I move, Mr. President, that we show our feelings by rising and standing a moment in silence.

President Adams then presented the following concerning the "Rufus Phillips Williams Memorial Collection":

"RUFUS PHILLIPS WILLIAMS MEMORIAL COLLECTION."

Memorandum:—

The suggestion was made to Mrs. Williams that the New England Association of Chemistry Teachers might like to honor the memory of its former President, Mr. Williams, by purchasing a few articles of his to add to the Library and Museum by a modest appropriation from the treasury.

Mrs. Williams wrote that she was much pleased with this suggestion and she would add other items, if such action was taken by the Association.

In a later letter Mrs. Williams states she will be glad to present to the Association the gavel used by Mr. Williams when President of this Association. She offers three prizes to be awarded by the Association for the best pupil's scrapbook of chemistry items, amounting to $10.00, $3.00 and $2.00 annually. She suggests working for a Chemistry Museum such as that at Columbia, by getting interested teachers to take one subject, and she offers to take Photography. She suggests several travelling Chemistry exhibits and offers to provide the cases needed and to place in the treasury $50.00 to provide for bottles, boxes, marking specimens, etc. Mr. Williams had specimens of minerals which could be used in this way.

Finally, she says that any plan adopted by the Association to honor Mr. Williams will be welcomed and accepted by her.

It was then voted unanimously that a committee of four, consisting of Miss Laura B. White, Frederick C. Adams, Lyman C. Newell and Alfred M. Butler, wait upon Mrs. Williams to take up with her the matters mentioned in the above memorandum.

The report of the Committee on New Books follows:

REVIEW OF MORGAN'S CHEMISTRY.

By William Segerblom.

CHEMISTRY, an elementary text-book, by W. C. Morgan of the University of California and J. A. Lyman of Pomona College. 429 pages. Illustrated. The Macmillan Company of New York.

According to the preface, "the authors have been actuated by the feeling that the student should never be allowed to get the idea that chemistry is a science that dwells inside laboratories and acts chiefly in beakers and test tubes." They have tried to bring out the humanistic side of the science, because "the average individual is and will continue to be more concerned with things which are of vital human interest than with the abstract ideas of science, however deep-seated its truths." And they recognize that "to appreciate this side of chemistry an intelligent understanding of funda-

mental principles is necessary." "Believing that those things are most important which are most far-reaching, the authors have made rather more of reversible reactions and equilibrium than other texts have done," and they claim that their students have been most intensely interested in this phase of the subject. Though written by college men primarily for high schools the book "may be used to advantage by freshmen classes in many of our colleges." According to the authors, the book endeavors to encourage the student to think inductively. How well it succeeds only a careful reading from cover to cover, or better, a trial in class, can tell, because there are no directions for experiments given, nor is there a promise of a laboratory manual to follow.

The thirty-one chapters start with the customary order,—Matter, Energy, Oxygen, Hydrogen and Water, with Fire, Some Properties of Gases, and How Chemical Reactions Take Place, interwoven. Then follow in order chapters on chlorine, combination by volume and by weight, chemical formulas and equations (in chapter x.), sodium, a novel metal, the atmosphere and nitrogen, nitric acid and the oxides of nitrogen, ammonia, a theory and its uses, valence and equivalent weight, carbon, the compounds of carbon, and organic chemistry (nineteen pages). The following twelve chapters deal with the usual groups of acid-forming elements and of metals.

Eighty-four figures adorn the text. The line cuts are those ordinarily found in books of this class. The half-tones are in general above the average; those of the leading chemists are unusually clear. Unfortunately the one of Arrhenius does not show this man as we who met him last year know him, thus tending to detract a little from the value of the others. A few of the subjects selected for half-tones are unfortunate, e. g. Fig. 7, Oxidation, (a) Rapid Oxidation—Burning of San Francisco; (b) Slow Oxidation—Life and Decay, the latter showing birds nesting in the hollow of a tree. At first glance these few cuts give the impression that this book is of the same type as one called "a chemistry" and reviewed before our Association some time ago, but a more careful examination shows that this book of Morgan and Lyman is one that the teacher will be glad to have at his side for reference and for inspiration.

The chapters are generally short and are followed by well arranged summaries and by lists of questions that interest.

The mechanical makeup of the book is excellent. The paper is pleasant to the touch, and the type is clear, the combinations of different faces of type being unusually well selected. Typographical errors are noticeable by their absence.

The text reads easily and naturally, giving much information

without making the reader feel it is overloaded with facts. An examination of the text, necessarily incomplete, with reference to the purely chemistry part, shows this to be reliable, although "Avogadro's Suggestion" is spoken of in the text as "Avogadro's Theory" and in the index as his "Hypothesis." Structural formulae are used in several places and are not confined to organic compounds. The ordinary equations substitute the arrow for the equality sign. In the reviewer's mind it is doubtful if the use of three different fonts of type in the ordinary equations to show different states or conditions of the substances is really of greatest help; but on this point teachers may rightly differ.

An index,—attractive, full, and usable,—closes what will probably be to many chemistry teachers a helpful text.

INTRODUCTION TO GENERAL SCIENCE.

By Lyman C. Smith.

Percy E. Rowell, B. Sc., Macmillan, pp. 302.

This text is a compilation of the facts of elementary science, with suggestive directions for illustrative experiments. The book contains such material as most teachers of the subject would find useful, and much more than any teacher could probably put into a one year course in the subject.

Such a work must naturally be superficial and disconnected, both as a whole and in its parts. In this respect it could not serve as an inspiring ideal for either the teacher or the pupils. Such books can, at best, be useful only as economizers of time and effort under conditions not capable of treatment by more effective means. They can never supply the place of adequate skillful instruction by good teachers, dealing with classes of reasonable size under conditions of proper equipment.

A trained teacher, exercising his profession as a fine art, and keeping such a book in the background, with the value of real educative processes constantly in mind, might find this book useful as a collection of notes and material for fixing some of the habitual knowledge of science, but most of the practical exercises, some two hundred and ten in number, are of a rather trivial nature, and the book does not supply material for serious, elementary science practice, an element so essential to the successful development of high school pupils.

The author has prepared this text with care. He makes no pretences as to the educational value of his method of treatment. We agree with him that his book may serve as a helpful stimulus to inquiring pupils especially if these already possess a natural scientific instinct. As he expresses it, "All roads lead to Rome," with the name of the eternal city spelled roam.

SANITARY AND APPLIED CHEMISTRY. (BAILEY.)

By George A. Cowen.

This is a text book on the chemistry of water, air and food, written by E. H. S. Bailey, Ph. D., Professor of Chemistry in the University of Kansas, and published by the Macmillan Company.

The book contains 345 pages, has an excellent table of contents and is well indexed.

There are no illustrations of any kind in the book. There are numerous exercises to be done by pupils. These are scattered throughout the book. There are 164 of them in all.

Chapter one is a very complete study of the air, considering its weight, constituents, and impurities. Chapter two treats of all the ordinary kinds of fuels. These are followed by ventilation, lighting, water and water purification.

The chapter on sewage and the disposal of household waste and garbage is very good.

The material on cleaning, the various washing preparations, soap and bluing, is not found in the ordinary text-book.

The second part of the book, beginning on page 117, is devoted to the chemistry of foods. There are chapters on bread, sugars, fruit, milk, meats, non-alcoholic and alcoholic beverages.

The book is written in a simple style, easily understood. Though it is not a book that any of us will be likely to adopt for a text, it is a book that I want myself, and shall get. I consider it a valuable addition to the teacher's reference library.

REPORT OF COMMITTEE ON CURRENT EVENTS.

The following report was read by the chairman, Professor Lyman C. Newell.

Sulphur. "The Outlook" for June 17, 1911, contains an article by Booker T. Washington entitled "Child Labor and the Sulphur Mines," which is a unique description of the Sicilian sulphur mines and mining operations. A supplement to this article may be found in the Advance Chapter on "Sulphur," from "Mineral Resources of the United States for 1909," published by the United States Geological Survey (free on request). The latter publication also contains references to the literature on the sulphur deposits in Louisiana.

Potash. Apropos of the international discussion on potash, two recent articles on potash may be profitably consulted. The "National Geographic Magazine" for April, 1911, contains an illustrated article on "American Potash for America," and the Advance Chapter on "Potash Salts," from "Mineral Resources" for 1910, contains an account of the German Industry. (An illustrated pamphlet describing the Stassfurt Industry may be obtained free from the German Kali Works, 93 Nassau Street, New York.)

White Lead. The Carter-White Co., Chicago, Ill., will send free on request a pamphlet describing their process of making white lead, and, if desired, a demonstrating outfit will also be given to a teacher of chemistry who will agree to use the materials.

Aluminum. An historical account of the discovery and development of the Hall process of manufacturing aluminum is in the "Journal of Industrial and Engineering Chemistry" for March, 1911; the same article is in "The Metallurgical and Chemical Industry" for February, 1911. Each article contains a portrait of Mr. Hall.

Ammonia. An exhaustive article on the manufacture of ammonia is in the "Journal of Industrial and Engineering Chemistry" (page 295), for May, 1911.

Boron. The preparation and properties of boron are fully described in the "Journal of Industrial and Engineering Chemistry" (page 299), for May, 1911.

Van't Hoff. Obituary notice in the "American Chemical Journal" for April, 1911.

Anaesthetics. A series of articles on anaesthetics by Prof. Charles Baskerville is in progress in the "Journal of Industrial and Engineering Chemistry." The following have already appeared: "Ethyl Ether," June; "Oxygen," July; "Nitrous Oxide," August. In "Science," August 11, 1911 (page 161), may be found an article by the same author on "The Chemistry of Anaesthetics," in which special attention is devoted to chloroform.

Bibliographies. A Bibliography of Science Teaching, Bulletin No. 1, 1911, Whole Number 446, contains a list of references to books and articles on the teaching of chemistry. A copy may be obtained on request from the United States Bureau of Education, Washington, D. C. The John Crerar Library, Chicago, Ill., has issued a "List of Books on the History of Science." Price, 40 cents postpaid. Address, The Librarian, John Crerar Library, Chicago, Ill. About twenty pages are devoted to chemistry, though many titles in other sciences bear upon chemistry.

Atomic Weights for 1912. The new table is printed in full in the "Journal of the American Chemical Society" for November, 1911. Niton (Nt) has been included and given the atomic weight 222.4. For reference we note that calcium becomes 40.07, iron 55.84, and mercury 200.6. "The changes are few in number and only in two cases are they large."

Monel Metal. This is an alloy which is said to be "less corrodible than bronze, strong as steel, that takes a finish like that of pure nickel, and of a uniform color." It is used for propellers, cylinder linings, and marine fittings. It can be forged, machined, soldered, brazed, welded and cast. (Sample shown.)

Professor Newell as curator showed examples of the uses and action of Bakelite, a new preservative to be used as a coating. Information concerning this may be obtained from the General Bakelite Company, 100 Williams Street, New York.

Mr. Zeller of the F. H. Thomas Company, Boston, then demonstrated the Balopticon of the Bausch & Lomb Optical Company, as well as displayed a large assortment of chemical and biological apparatus and glassware. An opportunity was given to inspect this during the intermission.

AFTERNOON MEETING.

The report of the Secretary follows:

ANNUAL REPORT OF THE SECRETARY.

During the past year the Association has held three regular meetings, one special meeting, and six Saturday excursions.

The thirty-ninth regular meeting of the Association was held at Boston University, October 22, 1910. Williams' "Essentials of Chemistry" and Meade's "Chemist's Pocket Manual" were reviewed. The opening address was given by Professor H. W. Morse on "The Experimental Basis of the Theory of Radioactivity." Mr. W. G. Whitman described some interesting new experiments. The closing address was delivered by Professor Latham Clarke on "Some Phases of the German Chemical Industry." The following officers were elected for the year 1910-1911: President, Mr. F. C. Adams; Vice-President, Mr. C. W. Goodrich; Secretary, Mr. E. S. Bryant; Treasurer, Mr. A. M. Butler; Executive Committee members, Professor F. L. Bardwell, Mr. Harold Bisbee, and Mr. G. A. Cowen.

The fortieth regular meeting was held January 28, 1911, at the Classical and High School, Salem, following a trip through the tanneries of the National Calfskin Company at Peabody, Mass. The addresses were by Mr. A. A. Claflin, who spoke on "The Manufacture of Leather from the Point of View of the Chemist," and by Mr. William Armstrong, who took for his topic "The Raw Material and the Finished Product."

The forty-first regular meeting was held April 29, 1911, at the Massachusetts Institute of Technology, Boston. Papers were read in memory of the late Professor Leonard P. Kinnicutt, and Dr. Ellen H. Richards, both prominent members of the Association. The members then listened to papers on "Svante Arrhenius" by Mr. L. G. Smith; "Electro-Chemistry and Its Recent Industrial Development," by Professor H. M. Goodwin; "The Elevation of Applied Science to an Equal Rank with the So-Called Learned Professions," a paper prepared by Dr. Ellen H. Richards shortly before her death; and "The Spirit of Alchemy in Modern Indus-

try," by Professor W. H. Walker. Honorary membership in the Association was conferred on Professor Svante Arrhenius and the following past-presidents of the Association: Professor Lyman C. Newell, Mr. Rufus P. Williams, Mr. Lyman G. Smith, and Mr. Augustus Klock.

A special meeting of the Association was held at the Parker House, Boston, April 28, 1911, in co-operation with the Eastern Association of Physics Teachers, to honor Dr. Svante Arrhenius of Stockholm, Sweden. The reception was followed by a banquet and speeches by Dr. Arrhenius, Mr. C. S. Griswold, Mr. F. C. Adams, Dr. L. C. Newell, Dr. G. C. Forbes, and Dr. W. F. Boos.

The members of the Association resident near Boston have been invited to participate in the following special excursions:

1. Saturday, December 10, 1910, to the Gas Show, Mechanics Building, where about forty members saw the method of preparing the incandescent gas mantles used in the Welsbach lamp, and examined many appliances for use with gas.

2. Saturday, December 17, 1910, to the South Station, where about thirty visited the various plants for making artificial ice, Pintsch gas, and for purifying the air and water used in the immense building.

3. Saturday, January 21, 1911, to the New England Gas and Coke Company, and the water gas plant of the Boston Consolidated Gas Company, Everett. About forty went over to the works to see the mechanical devices for unloading coal, loading and dumping cars, the Otto-Hoffman retorts, purification of illuminating gas, utilization of by-products (especially the ammonia by the Feldman process), then the gas generator, carbureter and superheater.

4. Saturday, February 25, 1911, to the Liquid Carbonic Company, Cambridge, where about twenty-five saw a little of the preparation of carbon dioxide, and several experiments in carbon dioxide snow, etc., by Professor Van Doren; thence to the Carter Ink Company, Cambridge, where the processes used in making ink, mucilage, paste, etc., were explained and illustrated.

5. Saturday, March 25, 1911, to the United Drug Company, Boston, where about thirty saw the processes for preparing and purifying drugs, and then examined the chocolate candy manufactory connected with it.

6. Saturday, October 21, 1911, to the New England Industrial and Educational Exposition, Mechanics Building, Boston.

The membership of the Association November 10, 1911, was as follows: honorary members, 20; active, 70; associate, 86; making a total of 176. Seven members are counted both as honorary and as active members. The total actual membership is therefore 169.

EDWARD S. BRYANT, Everett, Mass.

The report of the Treasurer follows:

REPORT OF TREASURER.

November 11, 1911.

Receipts—	
Balance December, 1910	$ 34.12
Dues, 1 Active, 1910	2.00
" 3 Associate, 1910	3.00
" 56 Active, 1911	112.00
" 56 Associate, 1911	56.00
" 1 Associate, 1912	1.00
Arrhenius Banquet	99.30
	$307.42
Expenditures—	
Envelopes, Stationary and Stamps	$ 21.89
Three Reports	89.75
Printing, other than Reports	26.85
Banquet	113.90
American Federation of Science Teachers	14.70
Miscellaneous	11.39
	$278.48
Balance November 11, 1911	$28.94

Respectfully submitted,

ALFRED M. BUTLER, Treasurer.

Mr. Butler called attention to the fact that a goodly number of members had failed to pay their dues, and that it is only through the receipt of dues that the Association will be saved from an increase in membership dues, as suggested two years ago. It has been only through strictest economy that the Association has been able to keep out of debt during the past two years. There have been many things left undone because of lack of funds, and the future, with the Museum, and fuller reports than those of the past year, requires more money than has been forthcoming. The delay in reports has been largely due to inadequate help for the Secretary in getting reports of lectures given at the meetings. All members in arrears are requested to remit the amount of their dues.

The Nominating Committee then reported, and a formal ballot was taken. This resulted in the election of the following officers for the coming year, 1911-1912:

President, Walter G. Whitman, Normal School, Salem, Mass.

Vice-President, Harold Bisbee, Dorchester High School, Dorchester, Mass.

Secretary, Ralph C. Bean, Girls' High School, Boston, Mass.

Treasurer, Alfred M. Butler, East Boston High School, East Boston, Mass.

The new President, Walter G. Whitman, taking the chair, then spoke of the good fortune of the Association in having present a representative of the Goldschmidt Thermit Company of New York. Mr. W. R. Hulbert then gave a most interesting and instructive talk on the subject of "Thermit," illustrating his remarks with several lantern slides, and two moving picture films, and closing them with several excellent experiments on Thermit itself. In these experiments the welding of two iron plates was clearly shown, and the dividing line between the steel and the slag above was most marked, the slag being easily knocked off.

Pamphlets explaining the process and experiments that could be performed in the class room were distributed. Anyone interested in these can easily secure them by sending to the Goldschmidt Thermit Company, 90 West Street, New York, N. Y. Titles of the pamphlets are "Thermit Practice in America" and "Laboratory Experiments with the Thermit Process."

Important among the recent developments in the industrial arts are the modern methods of joining metals of similar and dissimilar character. It is a case of the demand creating the supply. The traditional methods of joining iron to iron were by forging and burning on, but both those methods could deal only with metals of identical character.

Modern industry required not only means by which metals of dissimilar character could be joined, but also methods that should be more adaptable to varying requirements. In a comparatively short space of time, a number of processes have been presented, such as electric welding, various brazing methods, the Thermit process of welding, and welding by means of the blow pipe burning acetylene or hydrogen mixed with oxygen. All these methods are gradually sifting down to a state where each will take care of a special field of usefulness and while, in a broad sense, they all aim at the same results, and so might be considered competitive, the limitations imposed in each case by the source of power and heat restrict them to territories which overlap only in a few instances.

Distinguishing Features of the Thermit Process.

The method of obtaining heat and power in the Thermit welding process is based on the discovery that finely divided metallic oxides mixed in volumetric proportions with finely divided aluminum will, when ignited in one spot, produce a temperature of about 5,400° F. within half a minute without any supply of heat or power from the outside. The affinity of aluminum for oxygen is such that it will draw the oxygen out of the metallic oxide and combine

with it to form aluminum oxide, setting the metal free; and since the metal is the heavier of the two, it will sink to the bottom of the containing vessel. For welding purposes the metallic oxide used is iron oxide, and the reaction takes place according to the formula $Fe_2O_3 + 2\ Al = 2Fe + Al_2O_3$. This iron Thermit, commonly known simply as Thermit, will give half its weight as liquid steel.

The fact that no outside heat or power is required to produce superheated liquid steel, frees the application of the process from the necessity of setting on one or more fixed points at which to install its apparatus. On the contrary, the superheated liquid steel can be produced and applied for welding at any point desired and in any quantity. All that is necessary is to have containers or crucibles of sufficiently refractory quality and of various sizes to allow of the reaction of Thermit in quantities of from two or three to several hundred or even thousands of pounds.

The heat required to start the action is obtained by an ignition powder composed of Barium peroxide and aluminum bronze, a mixture easily ignited.

A distinctive feature of the Thermit process is, therefore, the transportability of the outfit to any given point, allowing the welding operation to take place without disturbing, in most cases, the fixed position of parts to be joined. Whatever the nature of the weld, whether on rails, on wrought-iron or steel pipes, on steel castings or steel forgings and, in some cases, machinery castings, the welding operation takes place while the pieces to be joined are in their working position. This gives the process a distinctive field of usefulness.

Method of Welding.

The operation, with the exception of a special variation in the case of pipe welding, proceeds on the same lines in all Thermit welding and may be shortly described as making a steel casting of superheated liquid steel around the parts to be joined. Owing to the high temperature of the liquid steel it will fuse with these parts and form upon cooling one homogeneous mass.

In performing the welding operation it is usual to proceed in the following manner. The parts to be joined are held in position, separated by an interval of from ¾ in. to 1½ ins. or 2 ins., according to their size. Around this space between the parts is then formed a mold, allowing for a reinforcement or "collar" which overlaps the adjacent ends of the pieces. The mold contains a gate so constructed that it will direct the liquid metal downward to the lowest level in the mold so that the superheated steel will rise from there up through the collar and, having filled the collar space, will flow up into a suitable riser. The riser must be large enough

to hold a quantity of metal equal to that forming the collar, or casting, itself.

The proper practice in making Thermit welds in this way on an industrial scale is to form the collar of beeswax, form the mold around this matrix and provide in the mold, besides a gate and a riser, a preheating hole. Into this preheating hole is directed a gasoline blow-torch, which melts out the wax, dries the mold and brings the ends of the castings to a bright red heat.

Rail Welding.

The application to the welding of rails as hitherto practiced in the United States relied entirely on supporting the joints by a Thermit shoe or collar, extending around the base and web up to the under side of the head of the rail. No attempt was made to join the heads of the rails beyond the ordinary care taken that, before welding, they should present a smooth and uninterrupted surface, in case of need by the introduction of shims.

The great advantage of the Thermit process of rail welding consists, of course, in the fact that the fusion between the Thermit steel and the rail material offers an ideal conductor for the return current through the rail. Furthermore, it was of immense advantage to street railway companies to be able, with the light and easily transportable equipment, to weld at one time as few and as many joints as they desired, practically without interfering with the traffic. Even where this method of welding has not been adopted in its entirety, the advantage of obtaining a rail-bond which at the same time can be utilized to give additional support to the rail ends at the joints, has led to its application in combination with regular rail-joints.

The most perfect rail joint will be the one that welds the entire section of the rail. The difficulty in achieving this result has always been that in order to do so it was necessary to interfere with the running surface of the rail. The latest method developed by the Thermit process minimizes this inconvenience to such an extent that it offers no practical objection. Welds of this kind, the so-called "solid section joint," have been made on Central Bridge in New York City under the most difficult conditions, on a bridge rail, in asphalt, on curves and on draw spans where the ends are loose, and have given perfect satisfaction under severe traffic conditions in several years' use. To obtain this joint it is necessary to separate the ends of the rails and to make the mold on the track. A riser has to be provided on the running surface of the rail but this is easily removed. The necessary appliances for performing such work are rather numerous but were all carried on a single two-horse truck.

Welding Steel Castings and Forgings.

It is in the method of making repairs on steel castings in place that the American practice has solved its own problems with conspicuous success. Right from the beginning of its industrial introduction in the United States, it was confronted with the question of how to weld broken locomotive frames without dismantling the engines. That problem may now be declared to be finally and completely solved.

A great step in the successful use of this method of welding was made when the means of drying the mold and bringing the casting to a high temperature were simplified so as to be performed in one operation. This was achieved as soon as the usefulness of a wax matrix in connection with making a mold had been learned. As before described, the wax is applied hot in the shape in which the reinforcement collar is to remain on the casting. By a suitable arrangement of wooden cores for the preheating gate, pouring gate and riser, the mold can be made on this wax matrix. The wooden cores, or sprues, are withdrawn and the flame of a strong torch is directed into the preheating hole. This melts the wax, dries out the mold and brings the ends of the casting to a bright red heat within the space of a few hours, even for very large sections. The preheating of the ends to be joined produces a better casting as it allows accumulated gases to escape before amalgamation with the Thermit steel takes place.

Of course, the use of this process in railway shops is by no means confined to the welding of locomotive frames in place. It has been found perfectly practicable to weld mud rings, and the welding of connecting rods and the spokes of locomotive driving wheels by the Thermit process is a regular practice with numerous large railway companies. It has also been found practicable to weld grease cups onto connecting rods, and broken heads onto cylinders.

Still greater can be the saving to ship owners, as the size of the operation by no means hampers the application of the process. The repair on which this method of welding has found its widest use in shipyards is that of broken sternposts. Before its development, a broken sternpost could only be temporarily patched or had to be removed entirely from the vessel, an operation which took weeks of time, in addition to the high cost of a new casting or forging, $1000 and upwards.

In spite of the opposition of conservative individuals and organizations and of rival industries, quite a number of these repairs have been satisfactorily performed, including the welding of fractured sternframes, sternposts, rudder posts, rudder frames and propeller shafts. A list of these repairs performed in North Amer-

ica during the past five years includes sternframes up to 6¾ × 11 ins., sternposts up to 13 × 16 ins. and shafts up to 9 ins. diameter. In some instances the whole operation, between dockings, has been performed in 48 hours, and costs from $40.00 to $50.00

Another use of Thermit is in mining towns in the West where the plants are far from the source of supplies, and where delays in waiting for broken parts to be sent away for repair or new ones ordered are costly.

It is also used in foundry practice to liven the moulten iron that has become cooled in standing.

Others repairs are, of course, too numerous to classify or describe. They have ranged from the largest fly-wheels broken through the spoke and rim to anchors, and dredge buckets, and from crank shafts (from 9 ins. to 20 ins. in diameter) and wobblers on rolls, to small repairs on truck frames, motor castings and axles.

Common Thermit is the Iron Thermit. Other kinds are Chromium, Manganese and Ferrovanadium Thermit. Also, besides the oxides, sulphides or chlorides may be used.

The cost of Thermit is $.25 per pound.

The slides shown consisted of repairs on locomotive frame, sternpost, locomotive driver spokes, rudder frame, stern wheel shaft, stern frame on Collier Hero mended in three places, shaft (1) with fracture cut out, (2) with mould about it, and (3) completed, making the biggest piece of work on a shafting, 14 inches in diameter, and lastly, the main bearing on a travelling crane 80 feet in the air.

Then followed two moving pictures, first of a repair job on a broken locomotive frame, and secondly the welding of trolley car rails. Both pictures brought out in fine detail the steps in the process. Those present were particularly fortunate in seeing these films which showed up the process almost as perfectly as if it were taking place.

It was unanimously voted that the hearty thanks of the Association be extended to Professor Kent, and to Boston University for their kindly help, and to Mr. Hulbert and the Goldschmidt Company for their part in the day's entertainment.